COLLECTOR'S EDITION

ASTRONOMY

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HALLEY'S COMET RETURNS

View It! Photograph It!
Tips on Choosing a Comet Telescope!

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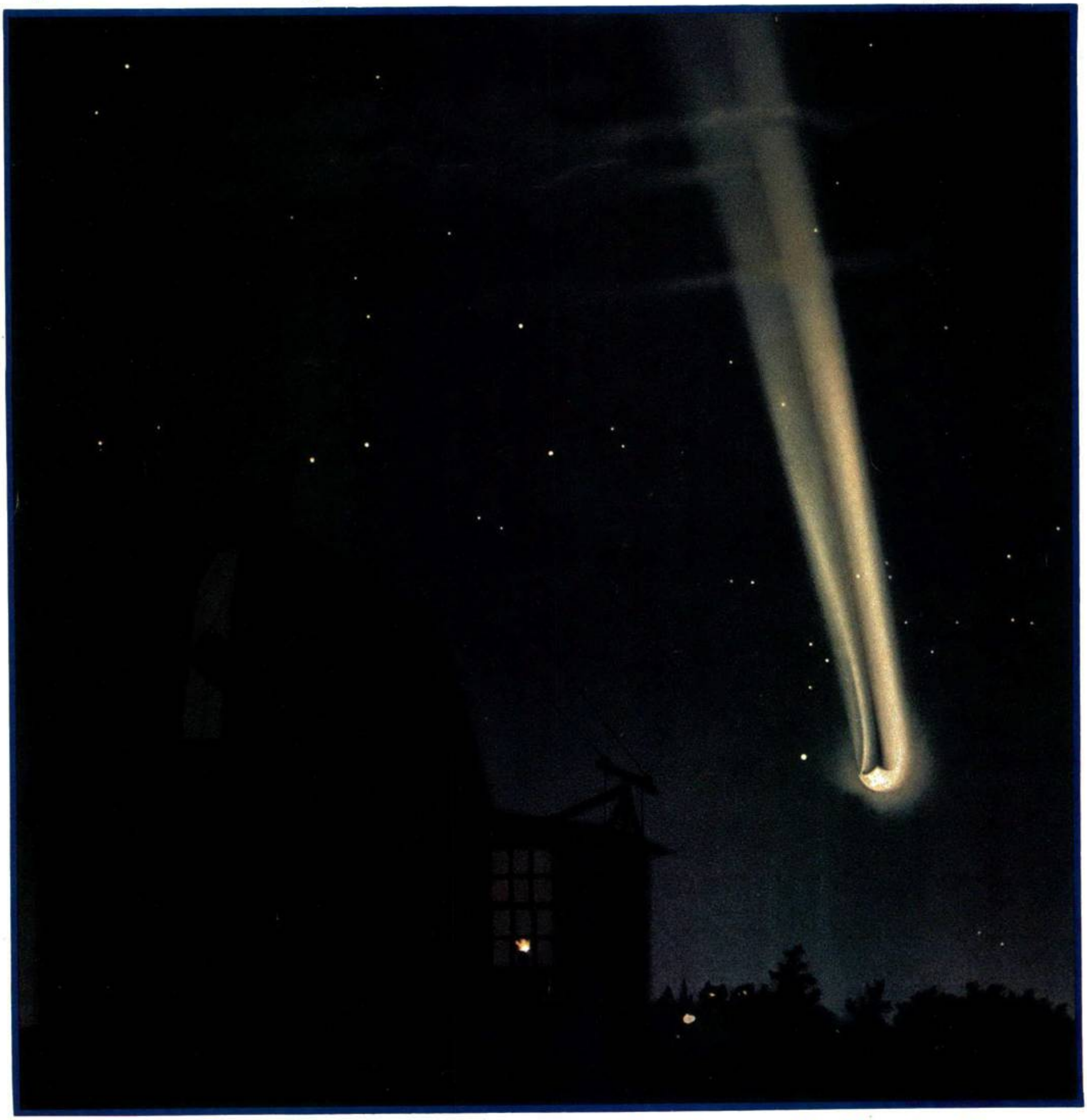

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All About Halley's Comet

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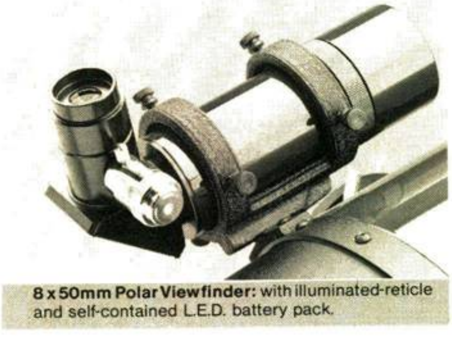
7 8 x 50mm Illuminated Reticle Polar Viewfinder: The illuminated, precisely-etched reticle scale permits extremely accurate polar alignment.



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14 Lifetime Warranty: Meade 8" and 10" LX3 Schmidt-Cassegrains, excluding batteries, *are warranted for life* in the U.S.A. and Canada. See the Meade General Catalog for details on this warranty — the most extensive in the industry.

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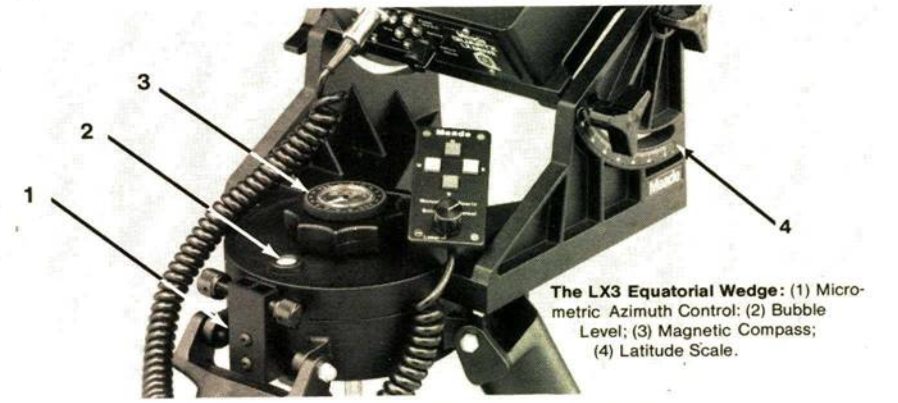

The LX3 Equatorial Wedge: (1) Micrometric Azimuth Control: (2) Bubble Level; (3) Magnetic Compass; (4) Latitude Scale.

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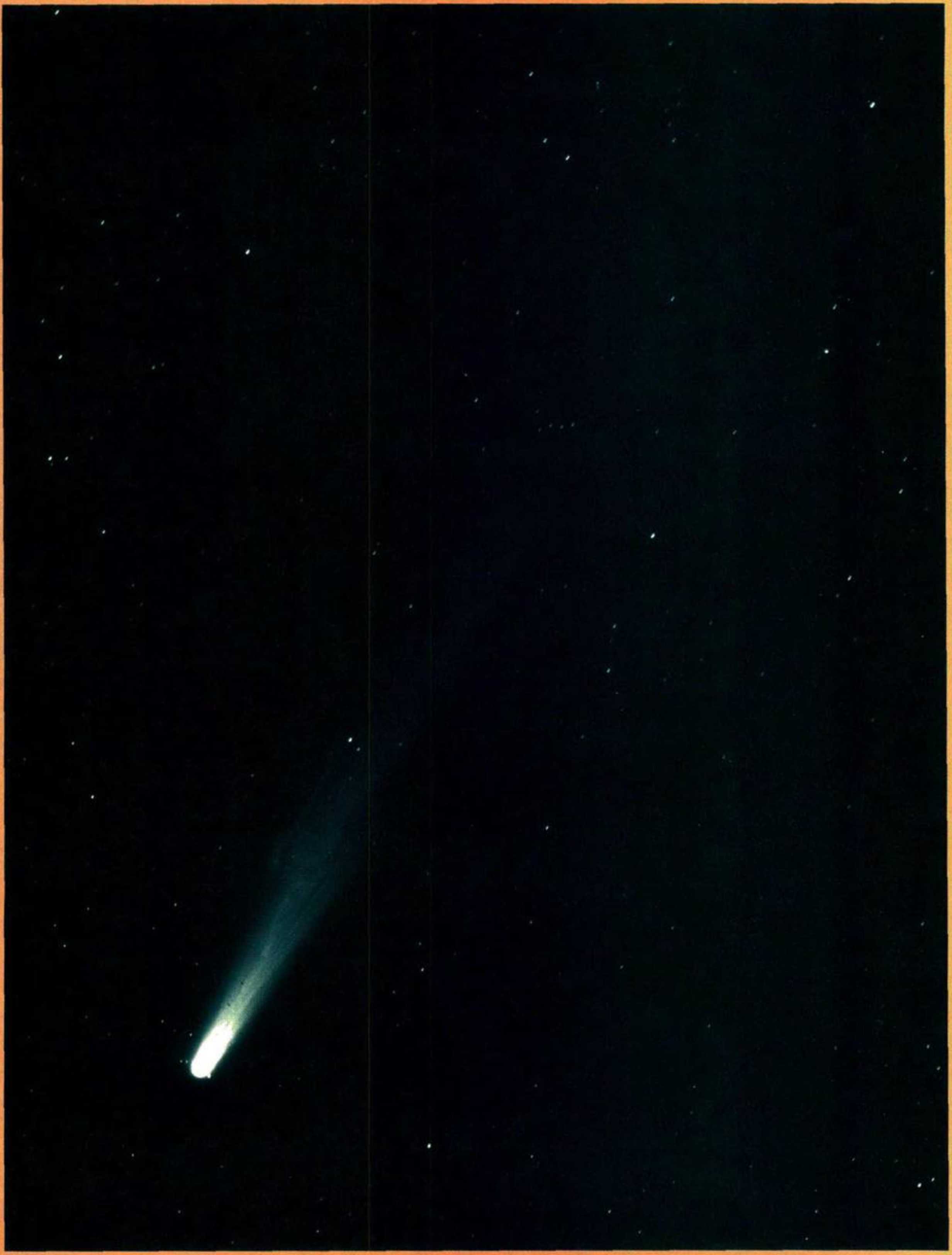

Halley's Comet, recorded in a 30-minute exposure on a blue-sensitive photographic plate, April 21, 1910. Taken with the 8-inch Bache photographic doublet at the Boyden Station, Harvard College Observatory, Arequipa, Peru.

ASTRONOMY

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Cover: The Great Comet of 1881. Courtesy of the Fairfield County Astronomical Society.

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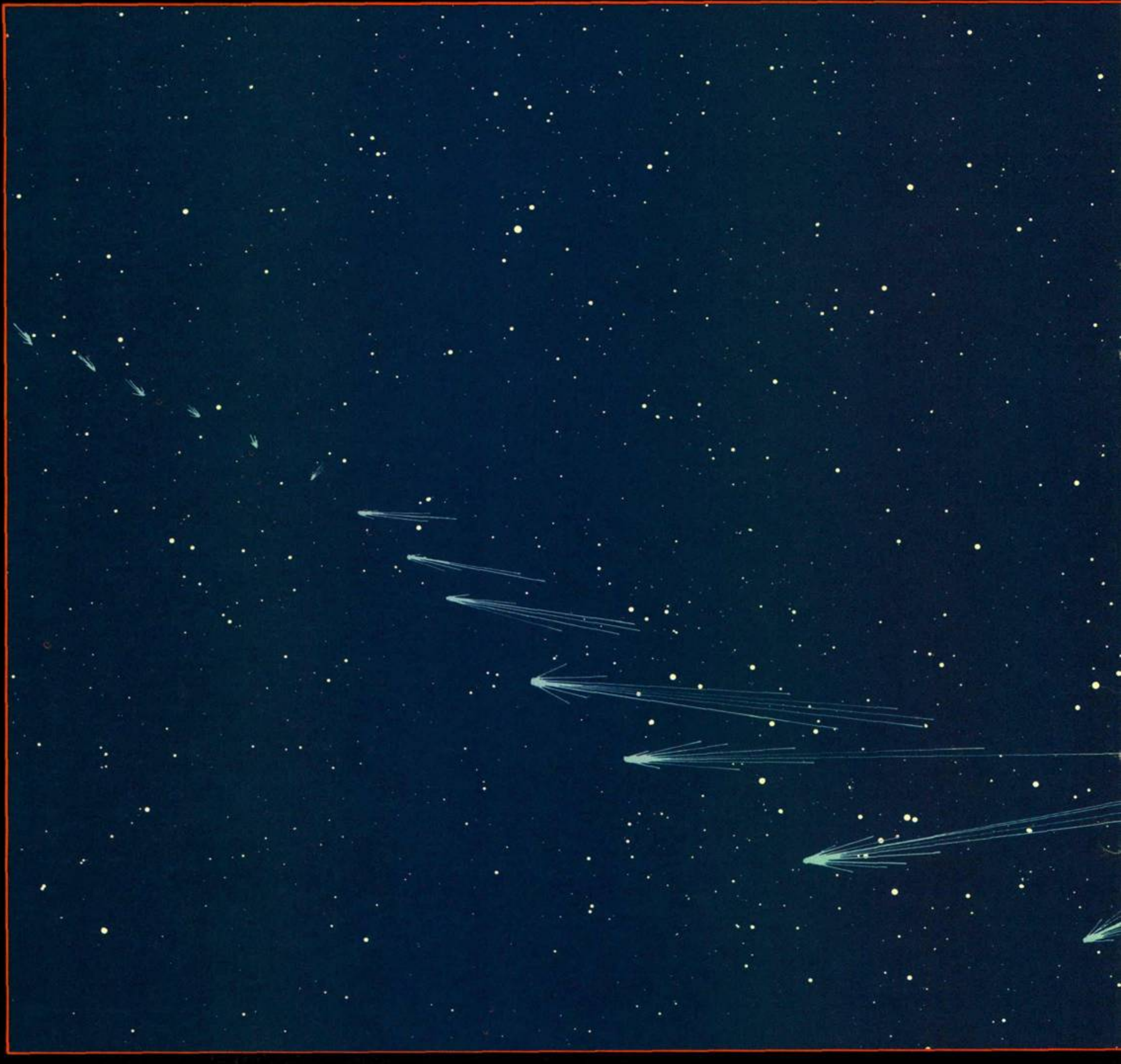

Don't Miss
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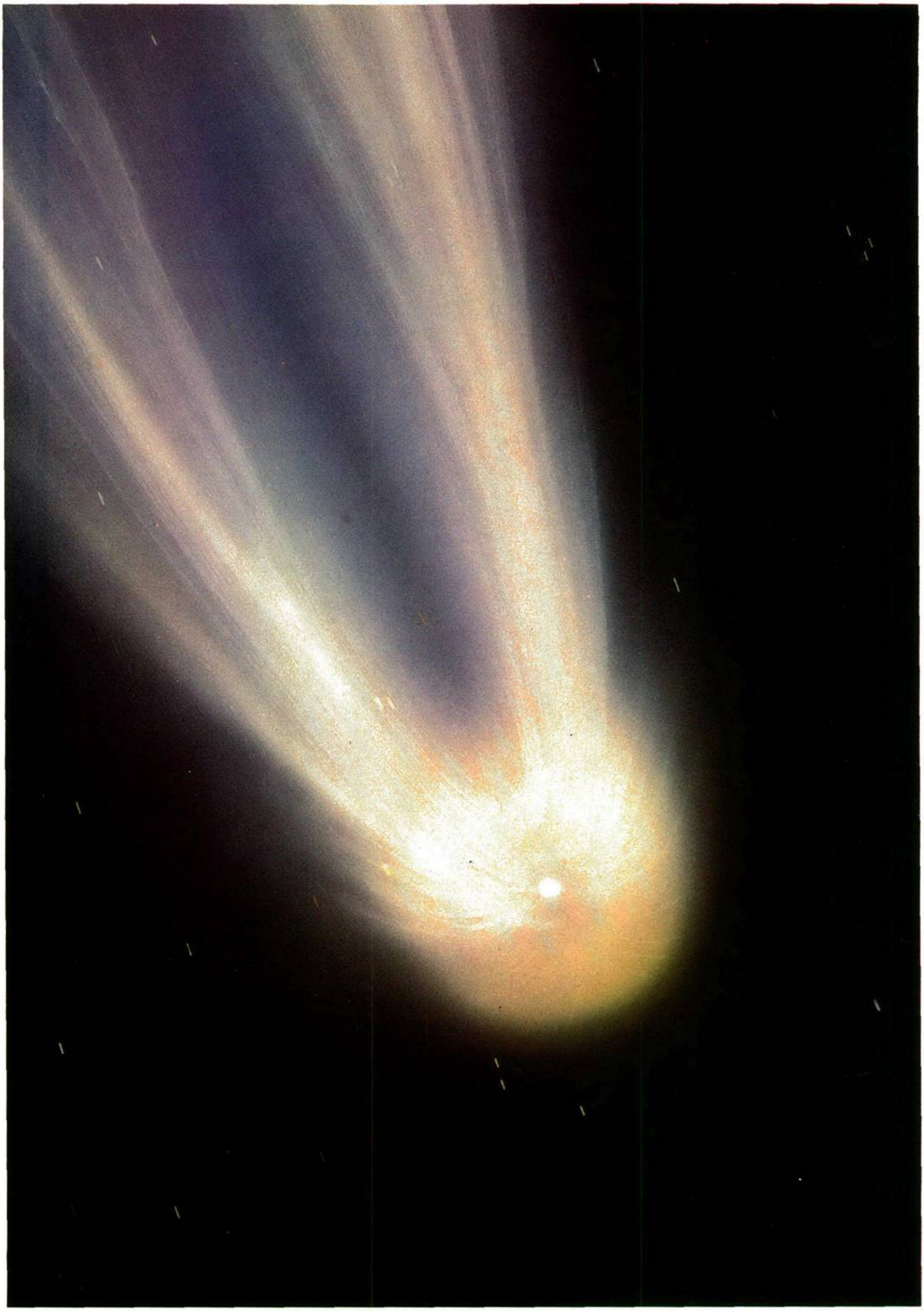
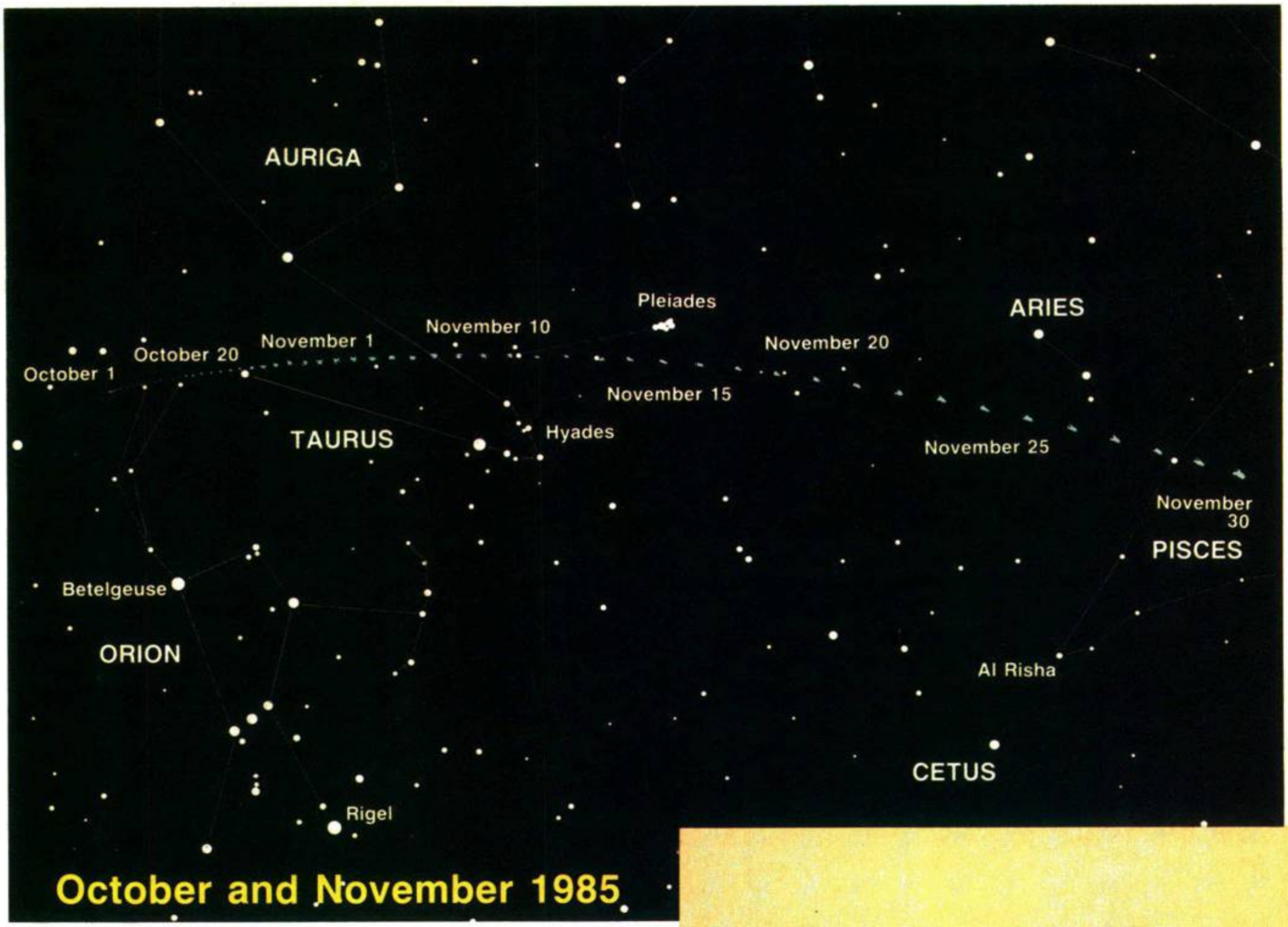


James B. Hartel



October and November 1985

Knowing exactly where and when to look is the key to seeing Comet Halley.

Halley's Comet is finally back. As it flies past Earth over the next six months, spotting it shouldn't be difficult — providing you know exactly where and when to look. Although no one knows for sure how spectacular the comet will be, or how long and bright its tail, astronomers know with certainty where to look for it. And that's what this article is about: knowing the right spot so you'll be sure to see the comet, whatever it happens to be doing.

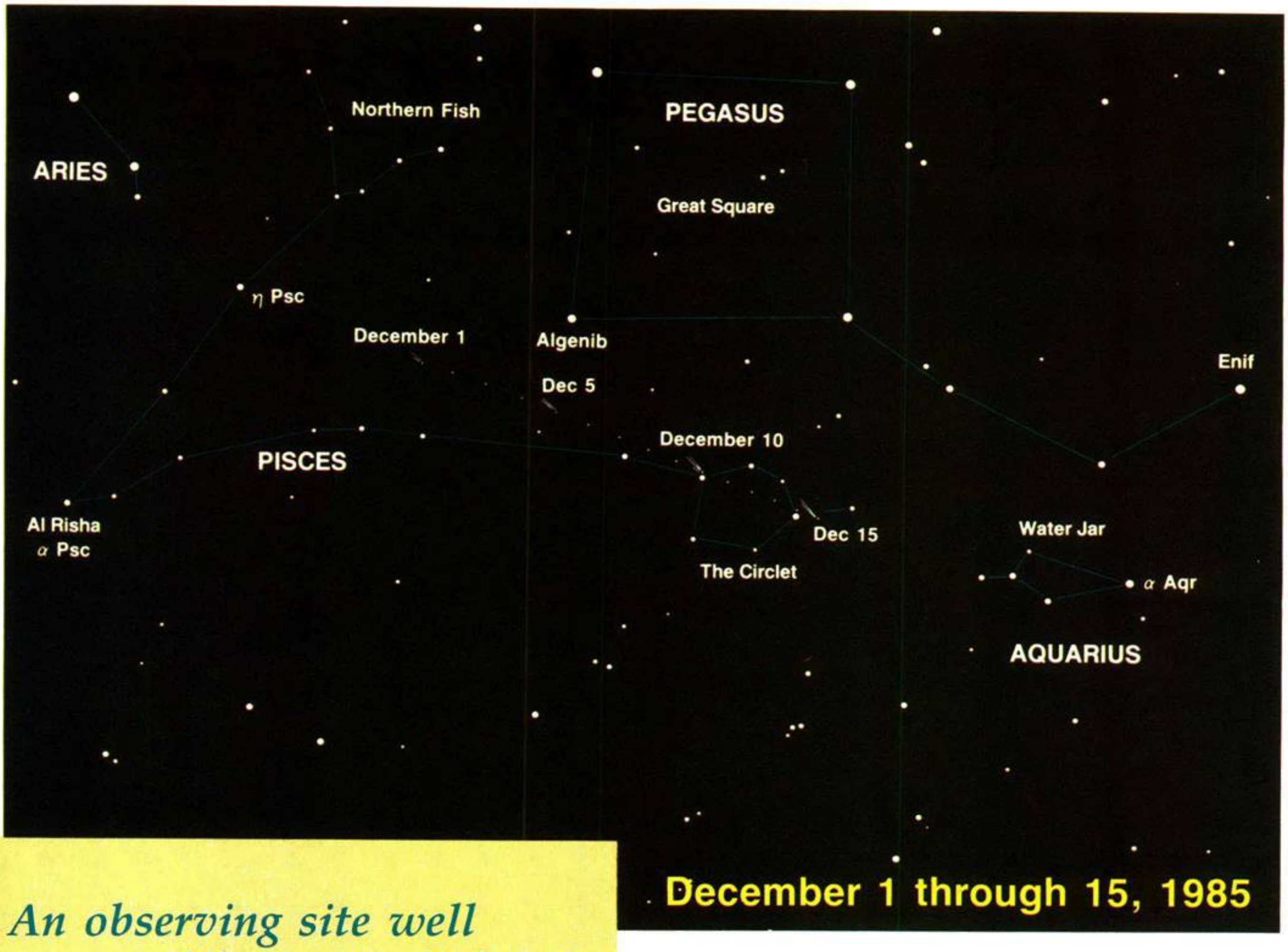
For observers in the United States, the very best viewing nights will fall in four roughly 12-day-long "windows," intervals when the comet's relatively bright and the Moon's not in the sky. These windows are: December 1 through 15 in 1985, and January 1 through 25, March 8 through 21, and April 2 through 13 in 1986. Mark these dates on your calendar now.

Additionally, if you know just where to look, there are two periods when you can find Halley with binoculars or a telescope: in October and November 1985 before it's bright enough to see by eye, and again in May and June 1986 as the fading comet leaves the vicinity of the Earth and Sun.

From now until January, you'll be seeing Halley on the inbound leg of its orbit, as it sweeps by Earth. Although it passes closest to the Sun on February 9, the comet won't be visible at that time because it will lie almost exactly on the opposite side of the Sun from Earth. In March and April, Halley will pass our planet on the outbound leg of its orbit; you'll be able to see it with the naked eye and can follow it until June with binoculars or a telescope as it recedes into space. For each of the prime "viewing windows" and the binocular viewing periods, you'll find a chart in this article showing the comet's path among the stars. All you have to do is look in the right spot and you should find it.

But there's more to it than just looking up. Although you will hear this over and over, it bears repeating here: you must find a place well away from bright city lights if you hope to see Halley as more than a ghost of its spectacular 1910 self. As a civilization, we have forgotten what a natural sky full of stars looks like. To see Halley's Comet at its best, you will have to become personally reacquainted with the magnificence of a star-filled night sky.

So you must first find a viewing site well away from the nearest city. This is important because when Comet Halley reaches its brightest, it will be low in the sky. If the sky is bright with city lights and full of air pollution, you won't stand a chance of finding it. Here's a simple test of sky quality: go outside and let your eyes get "used to the dark" for fifteen minutes, then look up at the night sky. If the sky looks dark and crowded with stars all the way to the horizon, then it's good enough for observing



December 1 through 15, 1985

An observing site well removed from city lights is absolutely essential.

Comet Halley. If you can see city glows around the horizon, you'll still probably see the comet, but not at its best. If the sky looks washed out and you see only a few stars in it, you need a better site. If you must observe near a city or its suburbs, it's best to be somewhere south of the city to place the glow of city lights where they will interfere least with the comet.

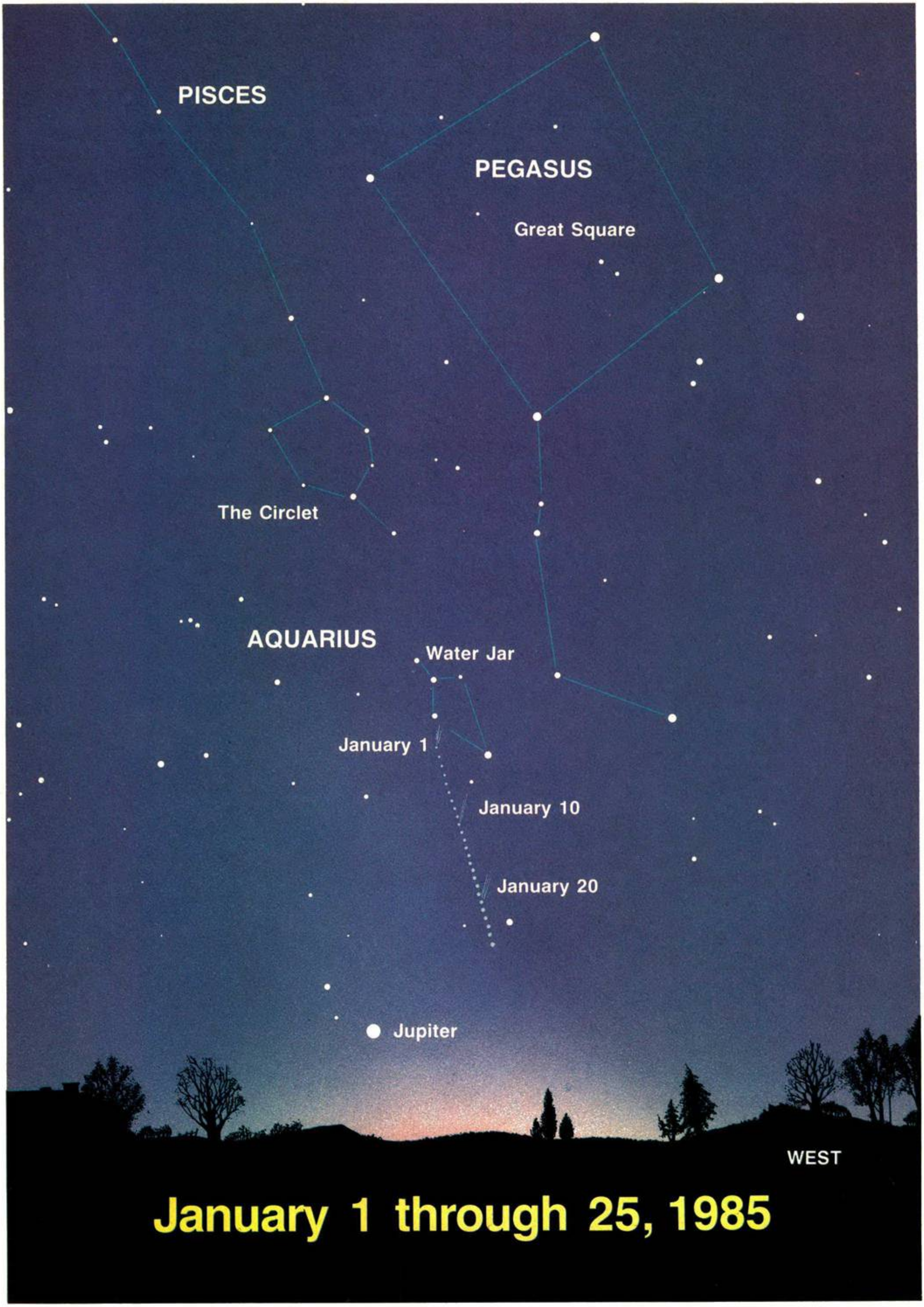
Ideally, your observing site should have a clear view to the east, south, and west, unblocked by trees. A hilltop or a low rise surrounded by open fields makes an excellent site providing the access roads are passable in winter.

Because the comet may not be very bright, you should learn to recognize the stars and constellations it will pass through. The constellations Halley will traverse between now and January — Taurus, Aries, Pisces, and Aquarius — are perfectly placed for viewing in October. If you consult ASTRONOMY's Star Dome star chart (in the center spread), you'll see these constellations stretching across the sky.

Our Star Dome chart is a circular "picture" of the sky. Stars straight overhead lie in the center of the chart, and stars near the horizon lie *around* the edge. The directions north, south, east, and west are labeled. In order to use the star chart without damaging your night vision, tape two layers of a brown paper bag over a flashlight to dim it, then step outside. Hold the magazine over your head, light it with the dimmed flashlight, and turn the chart so the directions at the edge of the chart match the points of a compass. This is not hard, but you'll soon get a crick in your neck. It really helps if you know someone who already knows the constellations and can point them out to you. In any case, don't get frustrated. Keep at it and you'll soon learn your way around the sky.

Even experienced amateur astronomers may need some practice in finding Pisces and Aquarius because these star groups are rather faint. Start by looking for Taurus, a bright constellation low in the east. That's where Halley is now. When the Moon is dark in November, the comet will be just north of the Hyades, which is part of Taurus. Higher than Taurus is Aries — two bright stars. Still higher you'll find the Great Square of Pegasus, nearly overhead. Using that as your jumping-off point, look for the Circlet of Pisces just south of the Great Square. (The Circlet represents the Western Fish in the constellation Pisces, The Fish.) From the Circlet, trace the line of faint stars eastward to Alpha (α) Piscium, then north to Eta (η) Piscium (a slightly brighter star) and to the loose group of stars representing the Northern Fish. During the December observing window, Halley will glide from Eta Piscium toward the Circlet. This is probably the part of the sky where you'll first see Halley with naked eye.

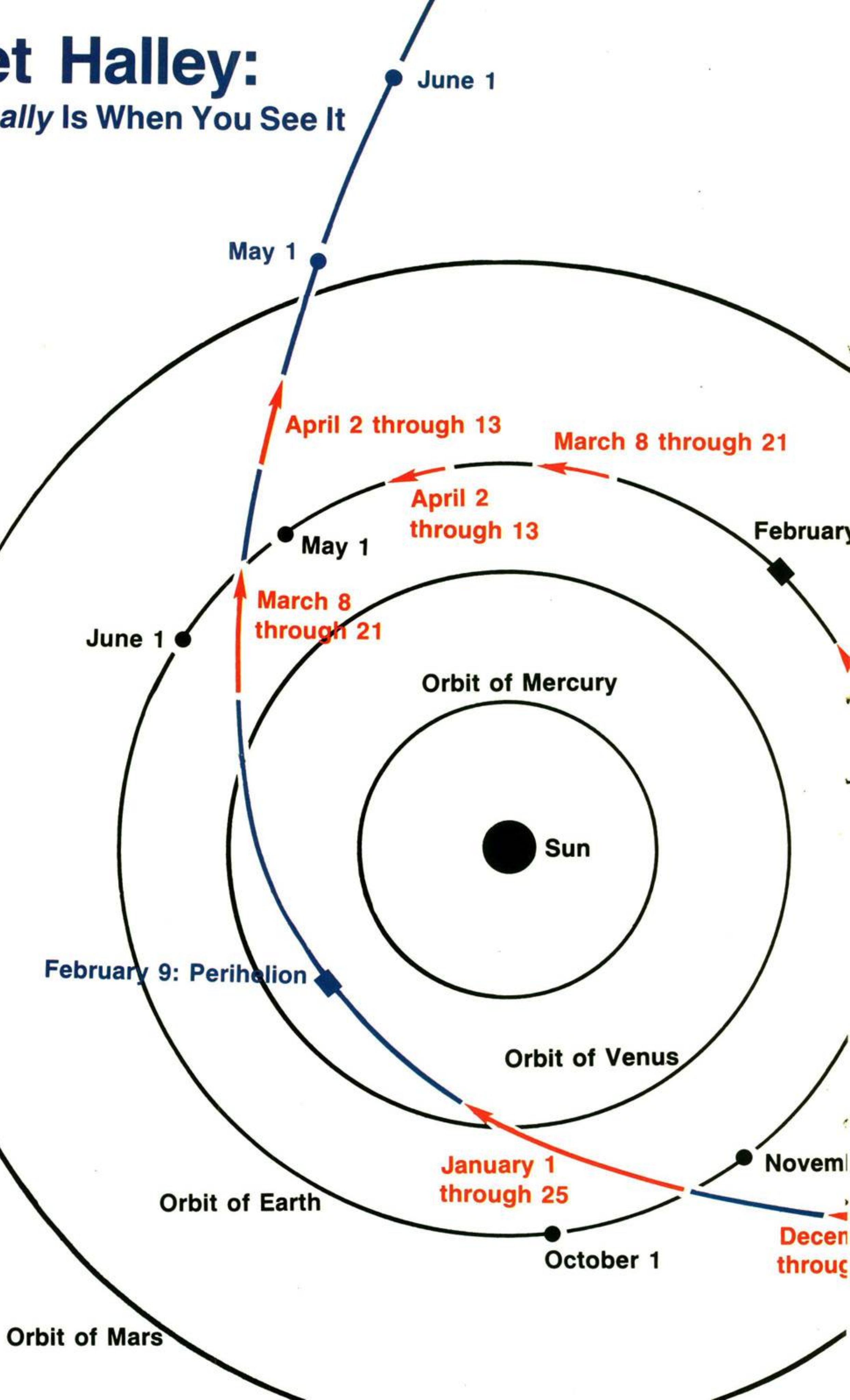
Aquarius is another large, dim constellation, but the tiny Y-shaped group of stars known as the "Water Jar" (plus nearby Alpha [α] Aquarii) is quite distinctive and located to the lower right of the Great Square. Halley will lie just below the Water Jar in January 1986, low in the

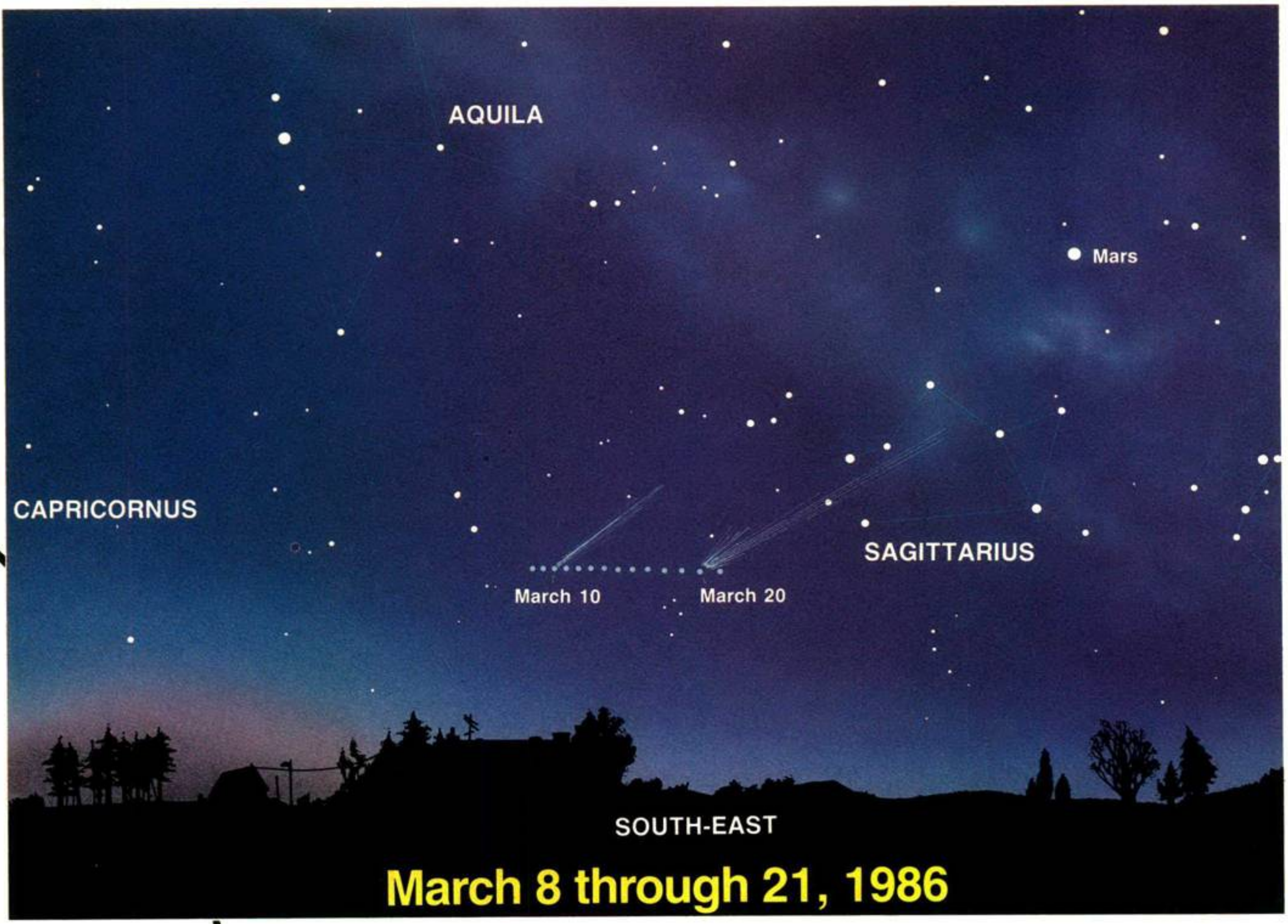

PISCES
PEGASUS
Great Square
The Circlet
AQUARIUS
Water Jar
January 1
January 10
January 20
Jupiter
WEST

January 1 through 25, 1985

Comet Halley:

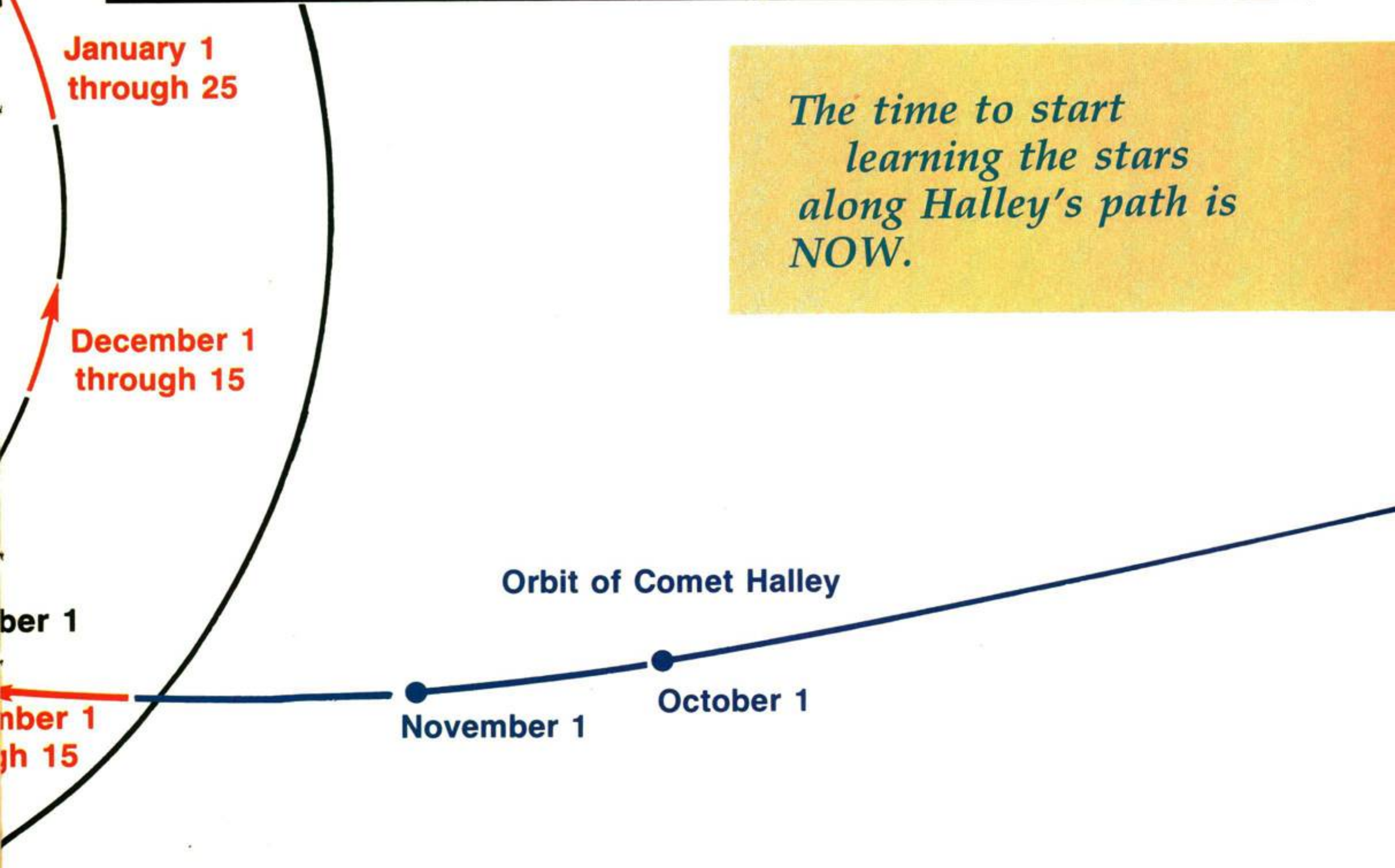
Where It *Really* Is When You See It

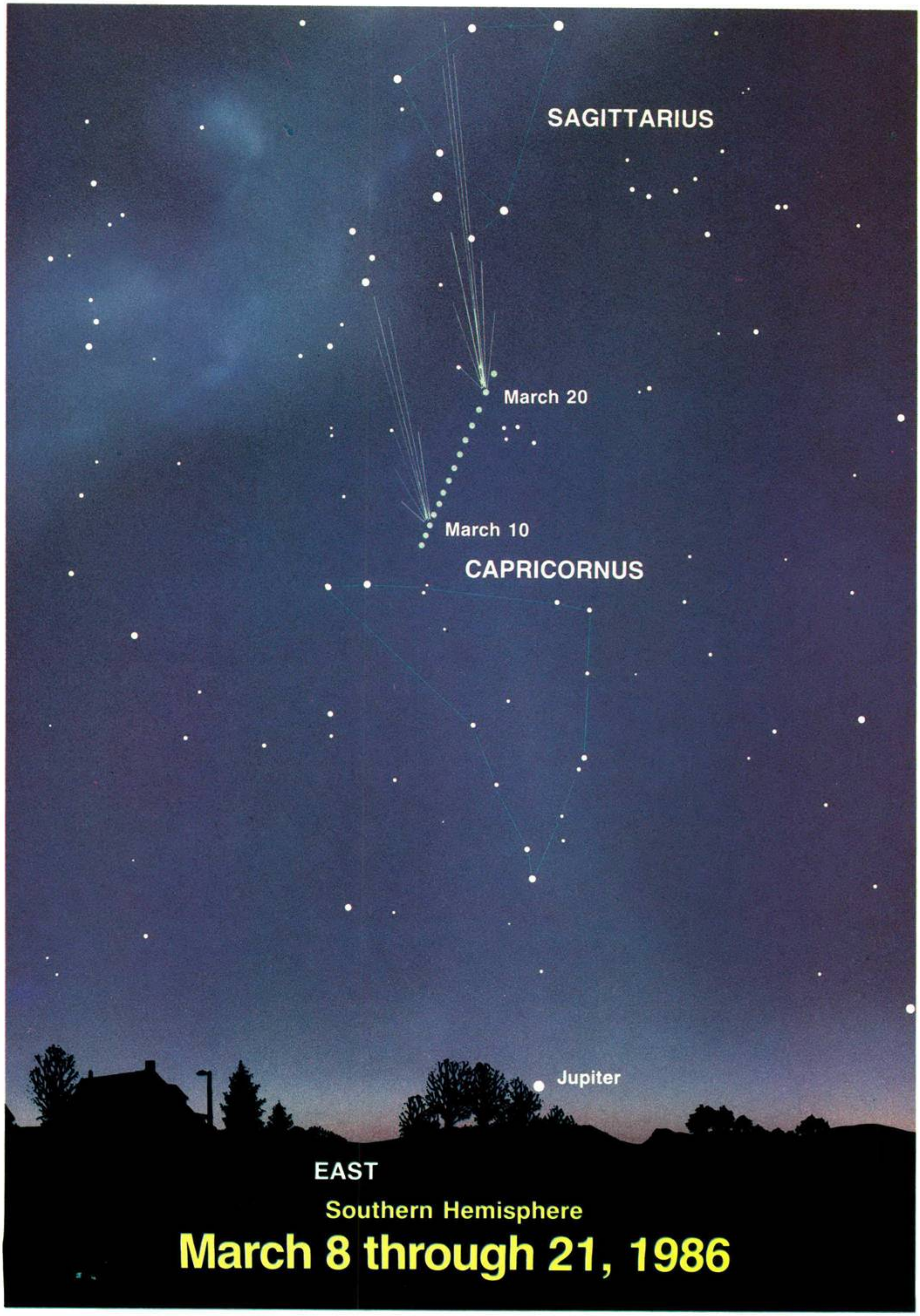

June 1
May 1
April 2 through 13
March 8 through 21
April 2
through 13
Februar
May 1
March 8
through 21
June 1
Orbit of Mercury
Sun
February 9: Perihelion
Orbit of Venus
January 1
through 25
Novem
Orbit of Earth
October 1
Decen
throug
Orbit of Mars


AQUILA
Mars
CAPRICORNUS
SAGITTARIUS
March 10
March 20
SOUTH-EAST

March 8 through 21, 1986

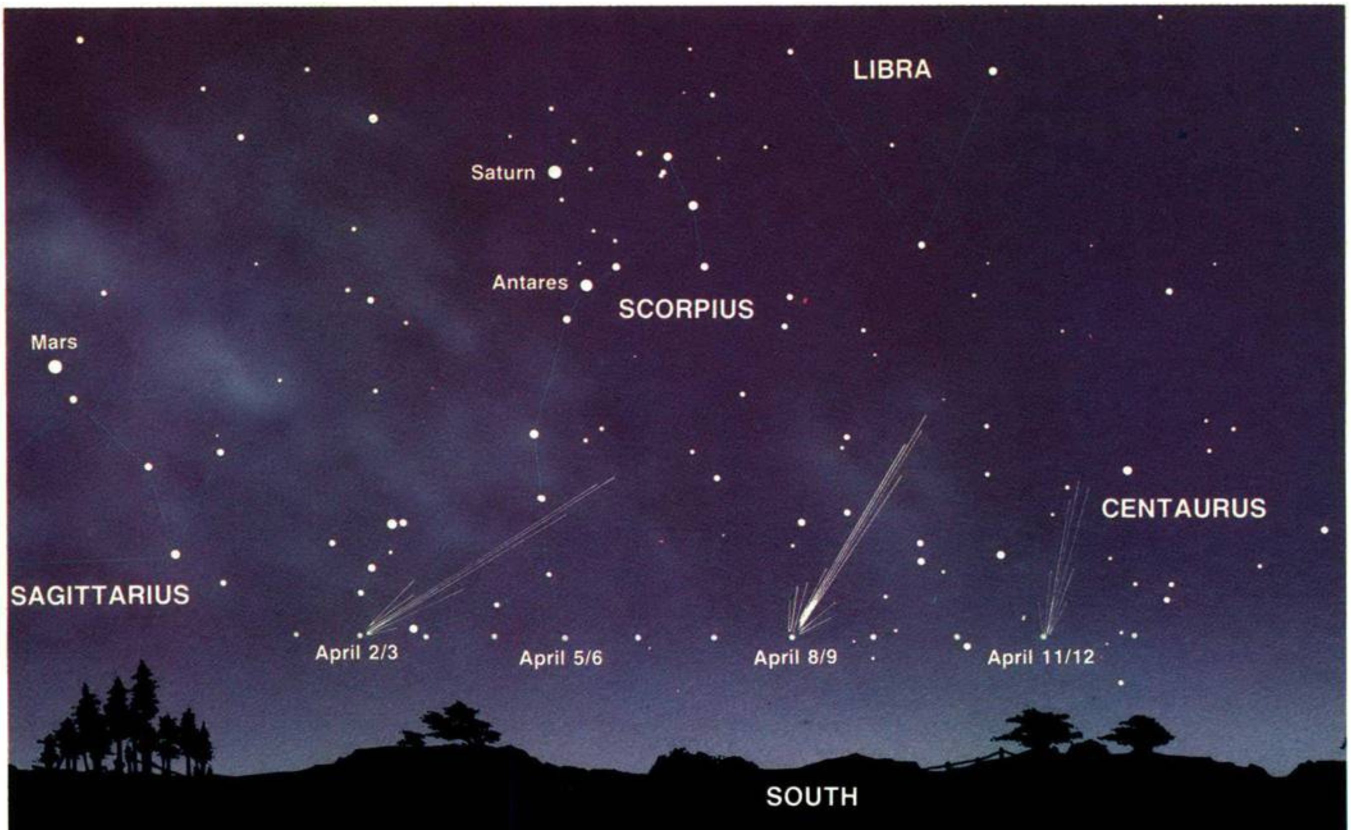
> *The time to start learning the stars along Halley's path is NOW.*


9
January 1
through 25
December 1
through 15
ber 1
nber 1
gh 15
Orbit of Comet Halley
November 1
October 1


SAGITTARIUS
March 20
March 10
CAPRICORNUS
Jupiter
EAST

Southern Hemisphere

March 8 through 21, 1986



April 2 through 13, 1986

Comet Halley will put on its best show for those who travel south of the equator.

evening sky right after sunset. Keep practicing until you're an expert at finding the Great Square in Pegasus, the Circlet in Pisces, and the Water Jar in Aquarius. This skill will serve you well, especially if the comet turns out dimmer than anticipated.

Now you're probably asking yourself — how do I look for a comet? It's actually quite easy. The charts show you where on any given date the comet will be against the background stars. Find the nearby stars, then carefully scan the area with your eyes, binoculars, or telescope.

You may not see anything at first, especially if you've just come outside and your eyes are not fully used to the dark. Normally, getting your night vision takes 10 to 15 minutes, and it will continue to improve for about an hour. Wait a few minutes until you can see better, then try again. While you're waiting, orient yourself by looking for the bright stars. And be careful not to "blitz" your night vision: avoid all bright lights.

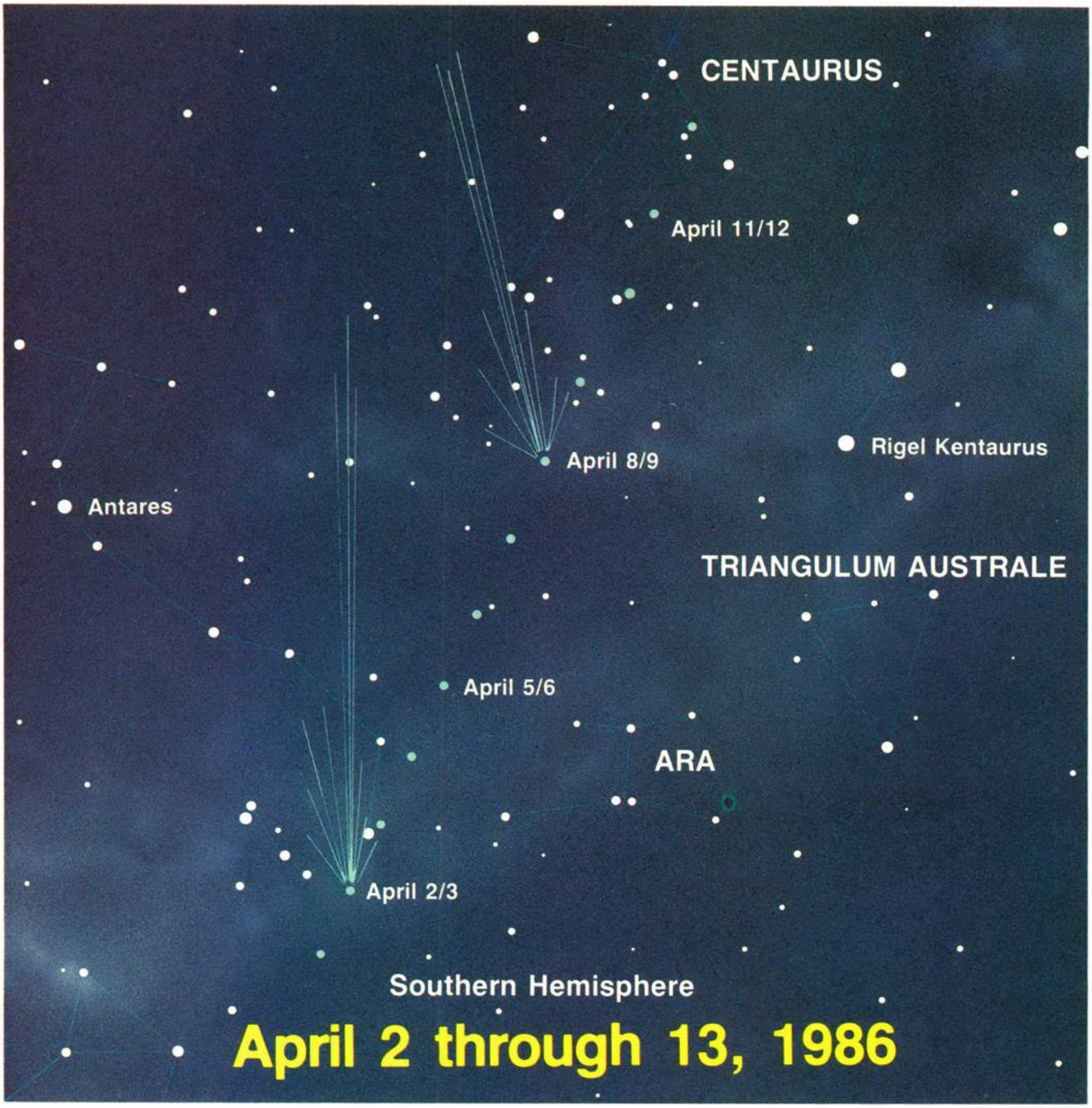
Now that your eyes are dark-adapted, locate the stars where the chart shows the comet, and slowly scan your view around the area. We'll bet that you will probably spot the comet when you aren't looking at it! This is because the part of your retina that works best for reading is not sensitive to faint light, though your peripheral vision is. What happens, then, is that you "see" a little glow of light when you're not looking right at it, but when you look at it, it disappears. This can be very frustrating at first, but you'll soon get used to looking beside things in order to see them. Astronomers call this "averted vision."

By now you're probably wondering about telescopes — itching to ask something along the lines of "Don't I need a telescope to see Comet Halley?" The answer is "No, not really, not if you just want to say you saw it." You should be able to see the comet in December and January, and again in March and April without optical aid.

However, any optical aid — even ordinary binoculars or spotting scopes — will be a big help in seeing the comet. A telescope will enable you to find Halley right away, follow it until next June, and see more of it than you could without a telescope. The reason is that the big lens or mirror gathers more light than your eyes can — helpful with faint celestial objects — and also enlarges the image so you can see details more easily.

Popular folklore to the contrary, Halley won't look like a blazing ball of fire through any telescope — even the biggest in the world — because comets simply don't look like blazing balls of fire! Comets are, by their very nature, rather faint and fuzzy celestial objects. A telescope will, however, make Halley appear bigger and brighter than it does to the unaided eye, and that's pretty important. For more information about getting a telescope, read "The 1985 ASTRONOMY Guide to Telescopes," starting on page 77 of this issue.

You should be aware that using a binocular or a telescope requires some practice. Start with the lowest magnification you can. Why? The higher the "power,"



the less sky you can see. This makes finding things harder, especially if you are not quite sure what you hope to see looks like. When you do find Halley, it will be a small fuzzy ball of light that moves gradually against the stars from night to night. You'll probably see it best using averted vision. Only in January, March, and April will the comet sport a glowing tail and be easily visible to the naked eye.

It's for those south of the equator that Comet Halley reserves its best show. There, viewing will be best in March and April, 1986, as Halley recedes from the Sun and passes Earth on the outbound leg of its orbit. We've provided charts for those viewing Halley during the southern hemisphere "windows" in case you plan to join a Halley viewing cruise or tour. Just as northern hemisphere stay-at-homes are doing, you'll find that getting to know the stars of Sagittarius, Scorpius, and Centaurus will aid you greatly in finding and viewing Comet Halley early next year.

Okay, you've now resolved to find a dark viewing place, learn a few vital constellations, decided to beg, buy, borrow, or steal a telescope to see Halley's Comet, and maybe you'll even take a trip to Australia or South America. So what's the big deal? What's this all about, anyhow? And just for the record, what *is* a comet?

The best answer astronomers can give is that comets are small, chilly bodies made of frozen gases, water, and dust. They measure a few miles in diameter and normally inhabit the outmost fringes of the solar system — in fact, comets are so small and so far out that we know they're there only because some of them get jostled and fall inward toward the Sun. As it heats in the Sun's glare, a comet's *frozen gases boil off* into space, glowing in the sunlight. As the comet gets closer to the Sun, its material steams away more and more actively, and then drifts out as a tail growing longer and longer. After swinging past the Sun, the comet cools off. Its gases stop boiling away, the tail shrinks, and it fades into obscurity in the depths of space. But not always.

Comets occasionally pass close to a planet, which alters the comet's orbital path around the Sun. A comet may be ejected entirely from the solar system never to return, or it may be flung into a closer orbit. Halley is such a comet: it now orbits the Sun once every 76 years. Halley's elongated orbit takes it closer than half the distance Earth lies from the Sun, then out past Neptune, three billion miles from the Sun. Since it loses material every time it comes around, it won't last long — maybe a few tens of thousands of years, an astronomical blink of the eye. But Halley has been in its present orbit over 2,000 years, and it's still going strong.

A bright, active comet like Halley consists of a tiny center called the nucleus, a halo surrounding it called the coma, and a long tail. The nucleus is the tiny icy body that causes all the fuss. It's the only solid part, and it's the brightest feature of the comet. The coma is the glowing globe of gases and dust enveloping the nucleus — very insubstantial by terrestrial standards. On long exposure photographs, the nucleus may be totally lost in the glow of the coma, but visually or through a telescope, the nucleus looks like a tiny star embedded in the hazy coma. Finally, the comet's tail tops off the picture. Atomic particles flowing outward from the Sun (the same particles that cause auroras and radio interference here on Earth; they're called the solar wind) blow the gases from the coma out into space, so comet tails always point away from the Sun.

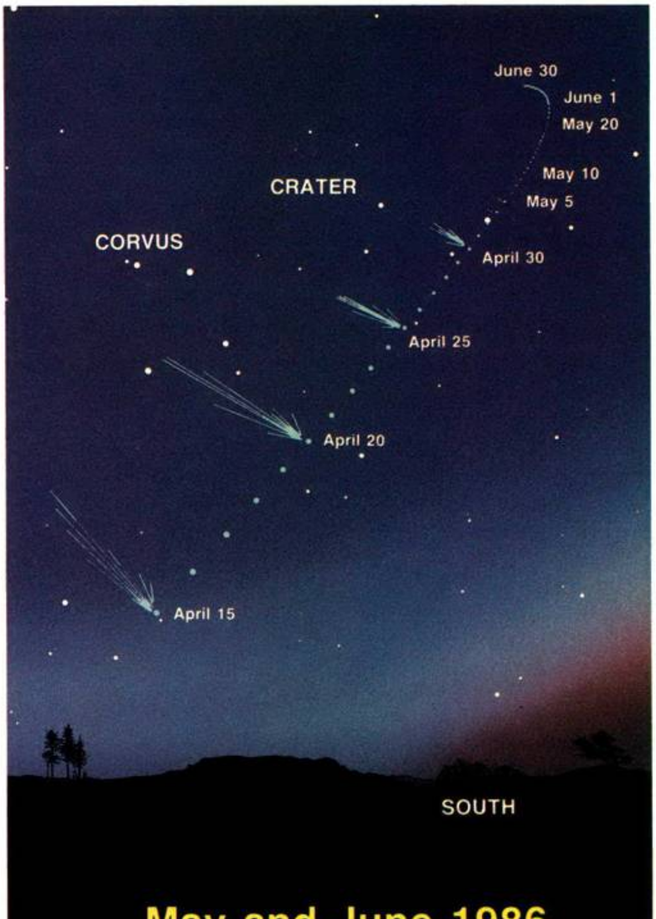
Let's now survey the viewing opportunities.

Comet Halley Inbound: October and November, 1985

During October and November, Halley moves steadily toward Earth, brightening rapidly. At the beginning of October, you'll probably need a medium-size telescope to see it. By the end of November, it could be an "easy" object in binoculars — easy, that is, for an experienced observer. But even astronomy neophytes should be able to find it with a small telescope.

October's Moon-free viewing "window" opens on the 11th, when Halley rises around 10 p.m. But you'll see the comet best just before dawn, when it will be nearly overhead. Halley is then in the northern part of the constellation Orion, moving slowly day-by-day westward against the background stars. Viewing it will be increasingly difficult after the 23rd, as the Moon approaches Full and brightens the sky. Use the finder chart on page 9 to locate it among the stars.

During November, Halley will rise at the beginning of full darkness and is highest in the sky around midnight. Good viewing begins on the 8th and ends on the 18th. During these 10 days, the comet is in Taurus. It passes north of the Hyades on the 10th, 11th, and 12th, then south of the Pleiades on the 16th and 17th. Halley will be getting steadily brighter — more than doubling in brightness during the observing window — and moving more quickly against the stars. It may even become bright enough to find with binoculars and will be readily visible as a soft, fuzzy glow in small telescopes.



May and June 1986

Be careful not to "blitz" your night vision.

Comet Halley Inbound: December 1 to 15, 1985

During December, Halley may become bright enough to be seen with the unaided eye — the first time since July 1910. The best viewing time will be as soon as the sky gets dark in the evening. Halley is located in Pisces, just south of the Great Square in Pegasus, as shown on the chart on page 10. At the beginning of the viewing window, you should be able to find Halley by scanning the region a short distance south and east of Algenib, the star in the lower left corner of the Great Square. Between the 12th and 15th, Halley will be in the Circlet, or Western Fish of Pisces. (Here's where knowing these stars comes in handy!) You may be able to make out Halley's tail (if it has formed by then) using binoculars or a small telescope.

Comet Halley Inbound: January 1 to 25, 1986

Halley sets approximately six minutes earlier each evening during January. On January 1, the nearly Full Moon won't rise until shortly after Halley sets, so the sky will be dark while Halley is up. On subsequent nights, the Moon will rise even later. Halley, by now showing a tail, will lie immediately below the Water Jar of Aquarius, which in turn lies below the Great Square of Pegasus. Start looking for the comet as soon as it's dark enough to see a few stars. At the beginning of the month, Halley will remain clear of murk near the horizon for less than two hours; by the 12th it will drop into the murk only 30 minutes after full darkness arrives.

The 12th also marks the return of the Moon — as a slender crescent low in the west — but you no longer have the luxury of waiting until the next observing window. On each successive night, the Moon will be brighter and higher in the sky, but Halley should have become bright enough that it will remain visible despite some moonlight. It should be fun to track Comet Halley as it moves into the evening twilight. From a good site with dark, cloud-free skies, you may be able to see Halley as late as the 25th. The finder chart on page 11 shows Halley's plunge toward the Sun.

Comet Halley at Perihelion: February 9, 1986

Halley will be lost in the glare of the Sun during February. Unlike previous apparitions, when Halley passes nearest the Sun (or, as astronomers say, "reaches perihelion"), Earth will be almost exactly on the opposite side of the Sun. Therefore, Halley will be not only hidden from view, but also quite far from us.

There's more to astronomy than this one comet. Astronomy is something you can really get into.

Comet Halley Outbound: March 8 to 21, 1986

After passing the Sun, Halley re-emerges in the morning sky, low in the southeast before dawn, between Capricornus and Sagittarius. The comet will then be in the southern sky and traveling south, so the circumstances for viewing it in the northern hemisphere will be marginal. Nonetheless, it's worth a go because Halley, supercharged from passing close to the Sun, will be near its brightest. If all goes well, the comet's tail will rise above the horizon murk even if the nucleus is too low to see. Use the finder chart on page 13 to follow its progress.

The best sites in the United States will be those farthest south — Florida, Texas, Arizona, California, Hawaii — and preferably sites that are high and dry. The farther south you go, the higher Halley will be.

From the southern hemisphere, March is quite a different story. As morning twilight begins, Halley will be well-placed for viewing in the eastern sky. If you begin observing three hours before sunrise, you'll see the comet rise in all its glory. The Moon-free period begins on the 8th, though on the preceding mornings, you may wish to enjoy the sight of Halley rising with the slender crescent Moon. The finder chart on page 14 shows how Halley should look.

Comet Halley Outbound: April 2 to 13, 1986

Halley reaches greatest brightness in April. Although it will be moving away from the Sun, it is then approaching Earth — so we'll see it bigger and brighter. As it swings closest to Earth on the 10th, it will move rapidly across the sky. For northern hemisphere observers, however, Halley will be so low in the sky that it will be all but lost. Everything depends on where you live. For observers north of 43° North latitude, the nucleus and coma will never get above the horizon. Nevertheless, its tail, perhaps as much as 25° long, may stick above the southern horizon. If you live south of 35° North, you may get a pretty good look at Halley low in the southern sky, traveling between the tail of Scorpius and the northern part of Centaurus. Halley will probably be bright enough that you can spot it without charts, but just in case, we've provided you a finder chart on page 15.

The best time for viewing the comet — when it's highest in the southern sky — will advance about 30 minutes per night. From April 2nd to 7th, do your viewing in the hours before dawn. On the 8th, Halley is highest at 3 a.m.; on the 10th, 2 a.m.; on the 12th, 1 a.m.; on the 14th, at midnight; and so on. The Moon will brighten the sky after the 13th, but at this point you may wish to follow Halley every clear night — in spite of this lunar interloper.

For southern hemisphere observers, Halley's Comet will be highest at the same hours as in the northern hemisphere — but what a difference! Halley will pass high overhead, and by the 15th, it will remain in the sky all night long. In a dark sky, Halley should be a beautiful sight, its tail glowing against the bright starclouds of the Milky Way or the jewel-like glitter of the stars of Centaurus. On the 14th, Halley will pass near the giant globular cluster Omega Centauri and on the 15th, right in front of NGC-5128, a bright galaxy. The chart on page 16 shows its path.

Comet Halley Outbound: May and June, 1986

Halley fades rapidly in May and June. The Moon-free observing periods lie between April 26th and May 10th, and between May 25th and June 9th. Halley will be in the evening sky and highest soon after full darkness, as it traverses the sky south of Leo and west of Corvus. Use the chart on page 17 to follow the comet as it fades away. With a telescope, it should be fun to see how long you can track it, and by then, of course, you'll be an expert Halley spotter!

When Comet Halley finally sinks into the sunset next summer, most astronomers will heave a collective sigh of relief. But an intensive year of observation marks only the beginning for professional and amateur astronomers interested in where comets come from and why they behave as they do. The task of plowing through great masses of brightness measurements, photographs, observations from the great ground-based observatories, plus the gigabytes of satellite data stored on magnetic tape will then be just beginning — for at this apparition, Comet Halley will be the most intensively studied comet ever.

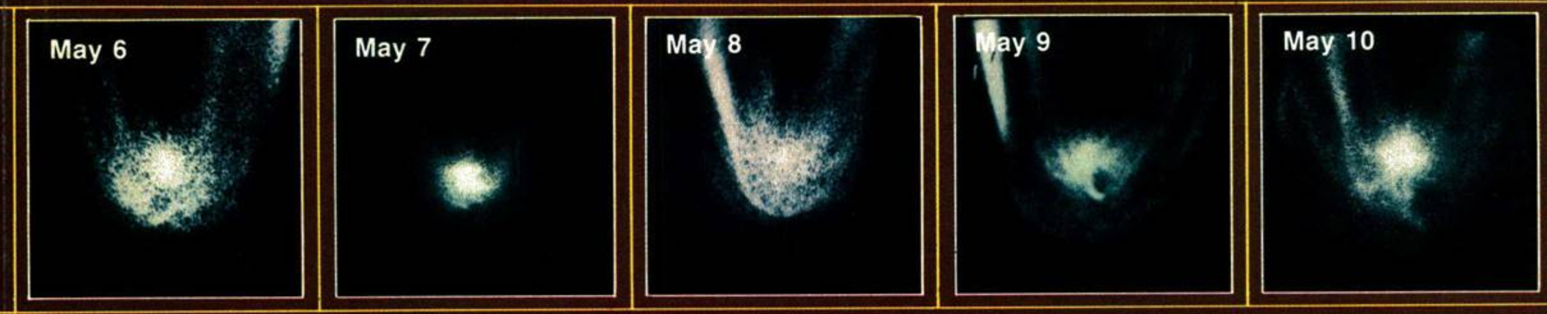
But something else will have started, too. Many of those ordinary people who simply wanted a "look at the comet" — and you may be one of them — won't forget those chilly nights under the stars watching a filmy wisp of light crossing the void. Captivated by the mystery and beauty of the heavens, you'll sometimes step outside at night for a glance or two at stars that have become a bit more friendly. Then, stirred perhaps by memories of a ghostly comet seen briefly on its journey around the Sun, you will take out the trusty binoculars or dust off the telescope and become a life-long lover of the stars.

Mt. Wilson

Old photos of Halley's Comet have given today's astronomers new looks into what happened when Halley flew past 75 years ago. (All nucleus photos courtesy of the authors; original photos taken at Mt. Wilson, Lick, Lowell, Helwan, and Vienna Observatories.)

Mining Old Silver: The 1910 Photos

by Stephen M. Larson and Zdenek Sekanina



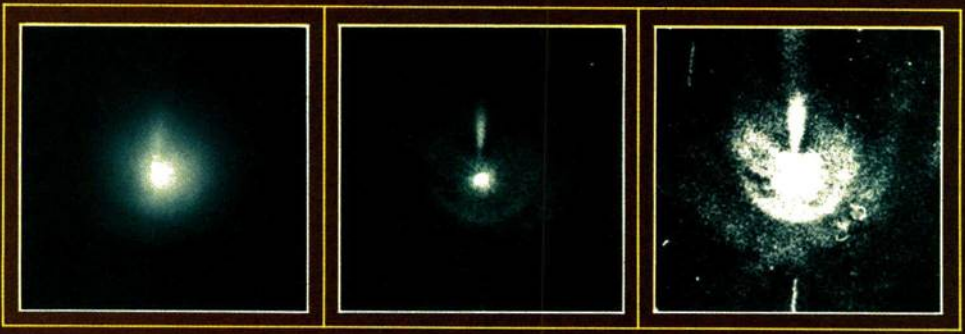
For almost 75 years, valuable data on the activity of Comet Halley's nucleus has lain hidden in the developed metallic silver of old photographic plates, essentially unusable. The secret to extracting this "buried treasure" is digital image processing.

By electronically scanning the 1910 plates, astronomers of today have reconstructed the evolution of dust jets ejected from the nucleus into the surrounding coma (see "Anatomy of a Comet," page 38, this issue) during the last apparition. We have even derived the comet's rotation period and the orientation of its spin axis. This has led to better estimates of the conditions the Giotto and Vega probes will meet at Halley next March.

In May 1910 when Halley passed closest to Earth, many observatories around the world photographed the comet, providing us with images at day by day — and sometimes twice a day — intervals. (There is a gap from May 16th to 20th, when the comet was too near the Sun for photography.) We collected many of these photographs, digitized them, and developed special picture-processing software to enhance the edges of faint, low-contrast features in the coma. The daily sequence of photos shown here was taken with telescopes ranging from the 60-inch reflector at Mt. Wilson to a 13-inch refractor at the Vienna Observatory. The original exposures ran from 30 seconds to 100 minutes; all the close-up photos are printed at the same linear scale.

What do they show? Typically, the photos display a bright, rather irregular center — the nuclear region — surrounded by the densest part of the expanding coma. Many of the photos show little "spirals" extending from the central condensation and often evolving into an expanding envelope. Our research leads us to think these are the edges of dust jets shooting out of the comet's surface layers under the heat of sunlight. The shells, jets, and streamers in the photos are all real — they can be seen on the original photos, albeit with difficulty, and are not artifacts of image processing. When the surface ice vaporizes, embedded dust is carried away from the

Lick

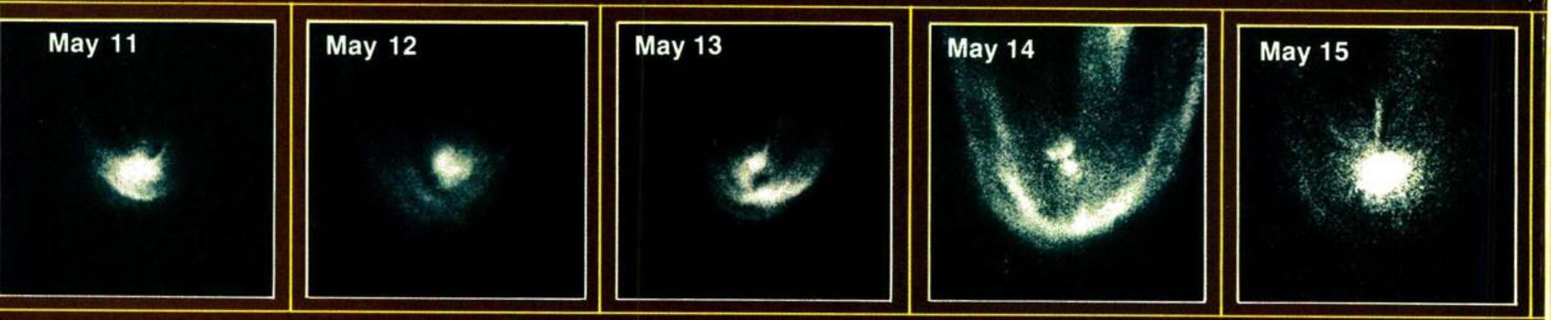


Straight print

Low-contrast processing

High-contrast processing

Mt. Wilson

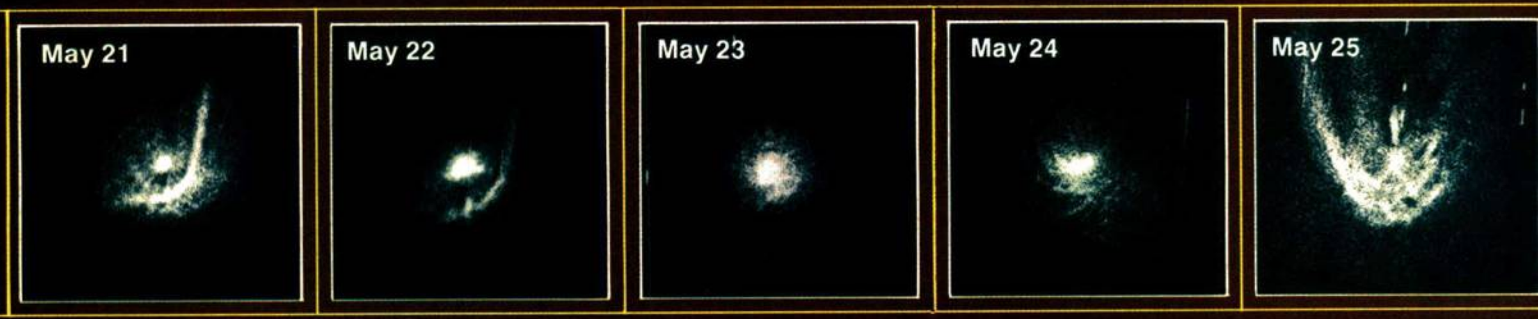


May 11
May 12
May 13
May 14
May 15

As jets eject material upward from the nucleus, the comet's rotation spins the material into a conical sheet. The solar wind then pushes on the sheet, bending it around the nucleus and eventually streaming it back into the tail.

Mt. Wilson

Below: Note the spoke-like structure connecting the nucleus and the shell in the May 21st picture, also the short jets visible on May 23rd and 24th. Calculations show these to extend several thousand kilometers.



May 21

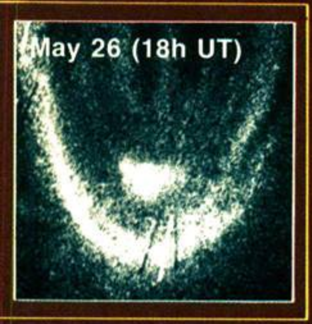
May 22

May 23

May 24

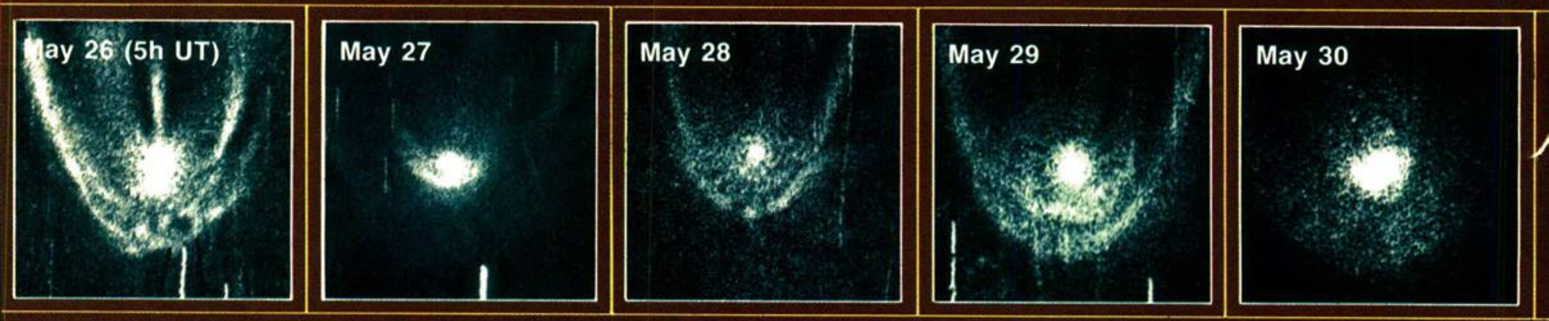
May 25

Lick


May 26 (18h UT)

Mt. Wilson

Far left: Note the changes in the coma's structure in 13 hours. Bottom: See how a "knot" in the tail, visible near the nucleus on June 6th, has fallen back and faded a day later.


ay 26 (5h UT)

May 27

May 28

May 29

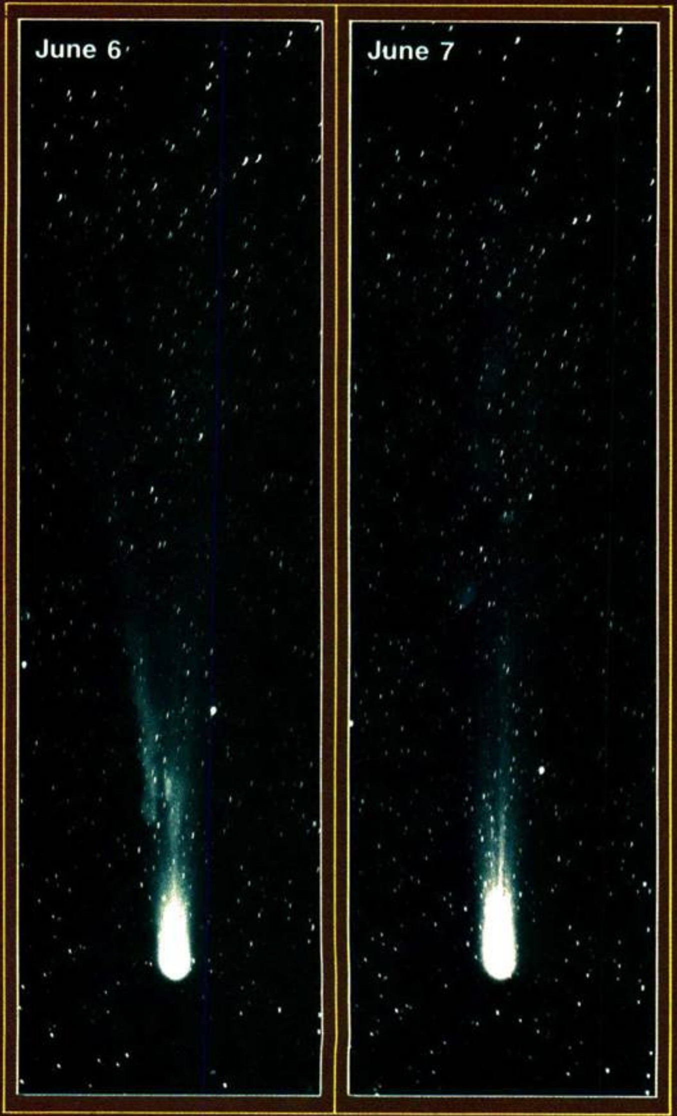
May 30

nucleus. The gas and dust soon separate: the gas swiftly dissipates, while the dust retains some structure longer and shows up on the plates as low-contrast features.

Our research involved running computer models to investigate how the ejection speed, pressure of the solar wind, and rotation of the nucleus all combine to control the ejected dust. We also turned the problem around — fitting the models to the images — and determined the rotation period of Comet Halley's nucleus and its orientation in space. For instance, on plates taken in early May 1910, we found one jet we could follow for several days. The mathematical model that best explains the phenomena in the photos is one in which the jet lies on Halley's equator, the nucleus rotates about once every two days, and the comet's north pole lies several degrees southwest of Beta (β) Ceti. The jet "turned on" May 6th at local sunrise and died out about 19 hours later.

What does this foretell about the Giotto encounter? The flight plan calls for the spacecraft to make what may become a kamikaze-style flyby: it will approach the comet nearly head-on and should zip past only about 300 miles sunward of the nucleus. The trajectory will send the craft deep into Halley's coma, where it may penetrate at least one dust shell on the way in. How long will the craft survive? No one knows, because no one can say with certainty how thick the dust will be. When the probe is closest to Halley, the northern hemisphere of the comet nucleus will be feeling the effects of sunlight most strongly, so this is where the dust activity is strongest. Luckily, the probe won't start flying over the comet's northern hemisphere — and therefore shouldn't run into really high, or even fatal, concentrations of dust — until just a few seconds before closest approach.

What will actually happen to the probe is anyone's guess, but no matter how the encounter goes, we should learn a lot about these fascinating celestial visitors!


June 6

June 7

Lick

Both planetary astronomers, Stephen Larson is at the University of Arizona's Lunar and Planetary Laboratory and Zdenek Sekanina works at the Jet Propulsion Laboratory in Pasadena, California.

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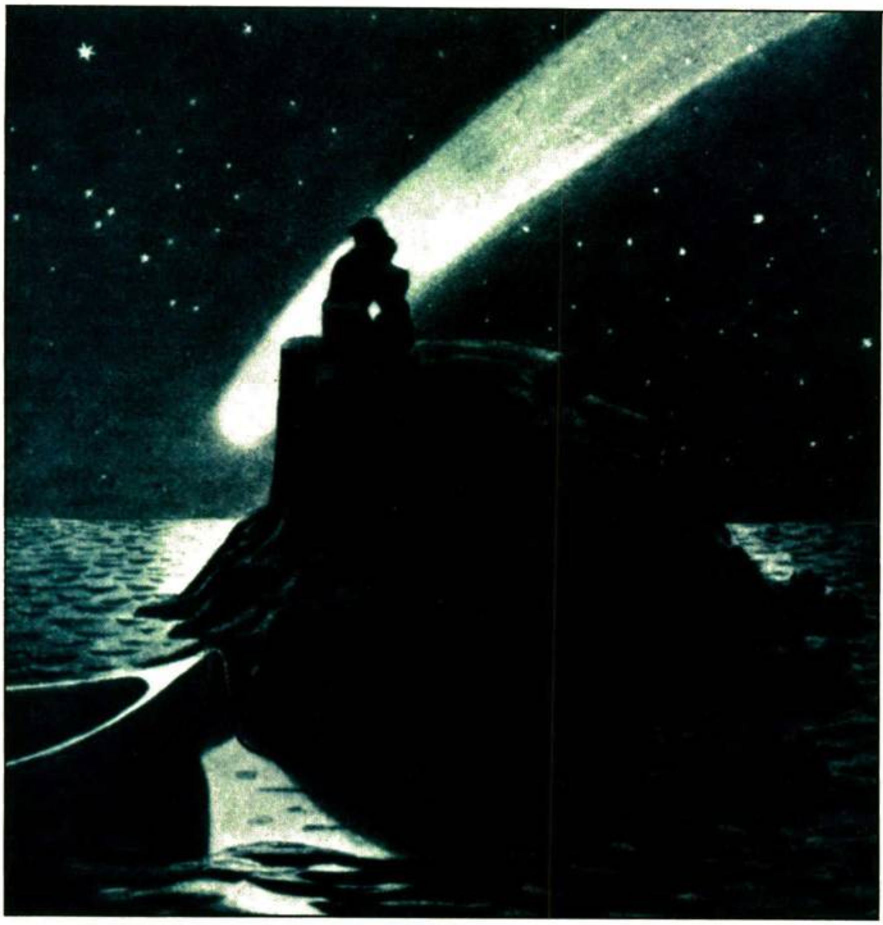
ASTRONOMY Forum



From *Harper's Weekly*, May 14, 1910; courtesy Library of Congress.

Waiting for the End of the World

Comet Halley — Beyond the Hype

"Remember, troops, it's going to get downright nasty out there," admonished the commander with all the raw emotion of George C. Scott at his best. "Lock all doors, bar the windows, and batten down the hatches. Above all — take your phone off the hook!"

All hands took this admonishment from their boss, the Observatory Director, very seriously. After all, Comet Kohoutek was still vivid in their memory. Most had been dreading the arrival of Halley's Comet and their unwilling role in the public spotlight, a role they knew all too well. Soon, despite the best efforts of public affairs officers, the microphones and TV cameras would find them once again. Their lines would be well rehearsed, but one would invariably get misquoted on the front page of the *Daily Planet* and all hell would break loose.

Little wonder the professional community is facing such a dilemma over Halley's Comet. If even one optimistic prediction about the comet's observability leaks out, the Ghost of Kohoutek could rear its ugly head. But on the other hand, is it *really* wise to tell John Q. Public not to look forward to Halley's Comet — an event he's awaited with anticipation ever since he was knee-high to a grasshopper?

With Halley's Comet coming into the home stretch, the debate rages on. Many professional observatories are avoiding the Halley limelight (can you blame them?), choosing instead to maintain a "business as usual" attitude in the wake of HalleyMania. But such efforts are proving futile, as the silence of astronomers' desolate mountain tops is broken by the incessant ringing of the telephone: "Which way do I look to see Hay-lee's Comet?"

A similar reluctance to get involved is sweeping the amateur community. After all, what privacy-loving hobbyist wants to have his name and phone number plastered all over Metropolis as the resident "expert" on Halley's Comet? As one Texas amateur astronomer put it: "My biggest concern about Halley's Comet will be which brand of beer I decide to pop when I go out to look at it."

Nonetheless, if all those who love astronomy can look beyond the T-shirts, gimmicks, and hype surrounding Halley's Comet, they may come to recognize the once-in-a-lifetime opportunity the Great Comet provides. It doesn't matter whether the view of Halley in the eastern sky sizzles or fizzles — the point is that we stargazers will never have a better chance to share our enthusiasm for the night sky with such a curious and (for now, at least) highly-receptive public.

And the science of astronomy could use a good promotional shot in the arm. You need look no further than the dwindling financial support of astronomical research and the mothballing of Mount Wilson Observatory to recognize that something must be done to resurrect public interest in the oldest science. The television series *Cosmos* and syndicated radio programs such as *Star Date* have helped raise public understanding of astronomy. Yet nothing can substitute for the old-fashioned, personal approach — learning the constellations and planets from a knowledgeable mentor beneath star-studded skies.

These days, the knowledgeable mentors — that's *you*, friend — are everywhere. Amateurs are astronomy's best promoters; they are friendly folks whose skill, knowledge, and enthusiasm offer bountiful resources for the beginning stargazer or telescope buyer. The biggest problem with amateur astronomers is that they're often hard to find.

Looking back on the Kohoutek era, things may have been very different had backyard observers been more conspicuous. After all, telescope sales boomed in the months leading up to Comet Kohoutek — a sure sign that the general public was actually getting turned on to astronomy. But while

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Expedition to Chile 10 days. With Dr. Sarah L. Garroway and Craig Small. Departs Friday, April 4, 1986. $1,858 (from Miami).

Highlights: 2 nights in Santiago and 5 nights in La Serena for concentrated viewing and photography. 12-day Chile and Easter Island program also available ($2,663). Optional extensions to Peru for both programs.

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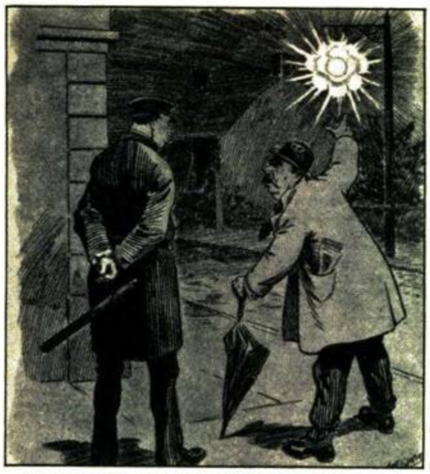


From *Puck*, May 11, 1910; courtesy Library of Congress.

Nocturnal wanderer: "Orfsher, 'blige me! Whish one er thosh is Halleysh Comet?"

most new telescope buyers were fingering their setting circles in bewilderment, amateurs were out at their observing sites having a grand old time watching Kohoutek — which, at magnitude +4 and high in the sky, wasn't half bad from a reasonably dark site.

The real problem with Comet Kohoutek wasn't that this celestial nomad didn't live up to its advance billing. Instead, it was *our* failure — as amateurs and ambassadors for astronomy — to inspire the comet-crazed public to discover the many things their shiny new telescopes were capable of showing them. The flood of post-Kohoutek used telescopes for sale was evidence of that failure. Had we been there, Comet Kohoutek might today be remembered as a catalyst for the greatest boom in backyard astronomy in the last half-century.

Halley's Comet can be the catalyst Kohoutek should have been. If we want the rest of the world to share our enthusiasm for the night sky, we have an obligation to ourselves — and our science — *not* to keep a low profile during the Halley apparition. Astronomical societies, of which there are hundreds in North America, should plan weekly star parties at well-known locations in big cities and small towns alike. Promoting these events should be no problem — with the crest of the Halley craze drawing near, star parties are certain to draw major press coverage in most communities.

The Astronomical League, a federation of 170 astronomical societies throughout North America, is challenging all amateur astronomers to take an active role in promoting the heavens to the public in the coming months. Societies and individuals wishing information on establishing programs to promote astronomy in their home towns should send a self-addressed, stamped envelope with 39¢ postage to the Astronomical League, P.O. Box 12821, Tucson, AZ 85732.

Regardless of what Halley looks like on this return, it is up to the astronomical community — and us amateurs in particular — to make this a positive experience for all.

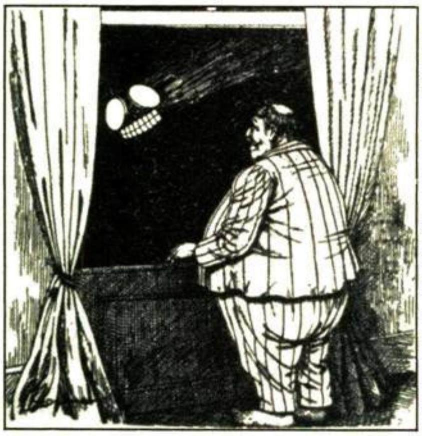
George D. Ellis
Donald R. Garland
Fort Worth, TX

Flammarion and the Comet's Poisonous Tail

> French Astronomer
> Camille Flammarion said,
> "We May Die Laughing
> When the Comet Comes"
> — Headline in the *Los Angeles Times* Sunday Magazine

In 1910, some people were afraid that Halley's Comet would collide with the Earth. Superstition led others to see the comet as a portent of coming disaster. But most people fearful of Halley's Comet were in terror of its *poison tail*.

On February 6, 1910, the director of Yerkes Observatory and his assistants trained their telescope on the comet to examine the spectrum of its gases. By comparing the varicolored lines of the comet's spectrum with the lines radiated by specific gases, a minute quantity of cyanogen was detected. When mixed with hydrogen, cyanogen produces the dreadful poison hydrogen cyanide, or prussic acid. A grain of its potassium salt *touched* to the tongue brings instant death. The comet's tail contained this gas.



From *Literary Digest*, April 30, 1910; courtesy Library of Congress.

The Comet is Now Visible at Washington

Their discovery was communicated to other astronomers and the public. The scientists asserted that the cyanogen would have *no effect whatsoever* upon life on Earth. Cyanogen commonly occurs in comet tails. The Daylight Comet of 1910, visible in January of that year, contained it, as had many others. The difference was that Earth was expected to pass through Halley's tail on the night of May 18.

The scientists — astronomers, biologists, chemists, and toxicologists — assured the world that it was absolutely impossible for any harm to come to anyone or anything. The facts were spread as far and wide as newspapers, magazines, pamphlets, and word of mouth could reach. Most people grasped the idea — but others experienced intense anxiety and dread. The reported presence of cyanogen was enough to create terror in the minds of the ill-informed. Why? Because noted French astronomer Camille Flammarion had predicted "The cyanogen gas would impregnate the atmosphere and possibly snuff out all life on the planet."

Who was this man whose theories and opinions spread fear among so many and created a storm of outrage among his fellow astronomers?

Most astronomers and many students of astronomy are familiar with Camille Flammarion's contribution to the queen of the sciences. He was the first major popularizer of astronomy, writing prolifically on a wide variety of related topics. His books such as *Real and Imagined Worlds* (1865), *Celestial Wonders* (1865), *Scientist Contemplations* (1870), *Catalogue of Movement in Double and Multiple Stars* (1878), *Sidereal Astronomy* (1879), *Popular Astronomy* (published in nine volumes from 1866 to 1880, then as a single volume in 1880), *The Stars, Volcanic Eruptions and the Earthquakes* (1902), and many other works brought new scientific theories and observations to the public's attention. Flammarion was a staff astronomer at the Paris Observatory from 1858 until 1883 when he founded Juvisy Observatory — where he worked for the rest of his life. Flammarion also founded the monthly publication *L'Astronomie* in 1883 and edited the bulletin of the Societe Astronomique du France from 1887 until 1925, the year of his death. His major observational interests were the Moon, Mars, and double stars, but his interests extended to what might be called "speculative astronomy" and he wrote three books about life on other planets, a topic still of intense interest and exploration.

He also wrote voluminously on life after death, reincarnation, and spiritualism. His writing applied scientific reasoning and argument to over 5,000 letters he solicited reporting contact with the dead.

Flammarion's last work, published in 1893 and 1894, was *La Fin du Monde* (The End of the World) which appeared in America as *Omega: The Last Days of the World*. The *Science Fiction Encyclopedia* called the book "a classic of the genre."

Flammarion's astronomy books dealt

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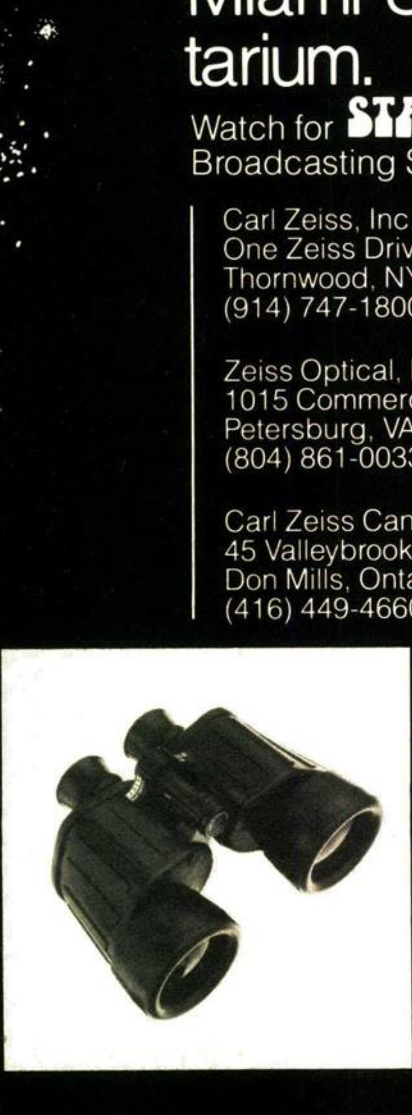

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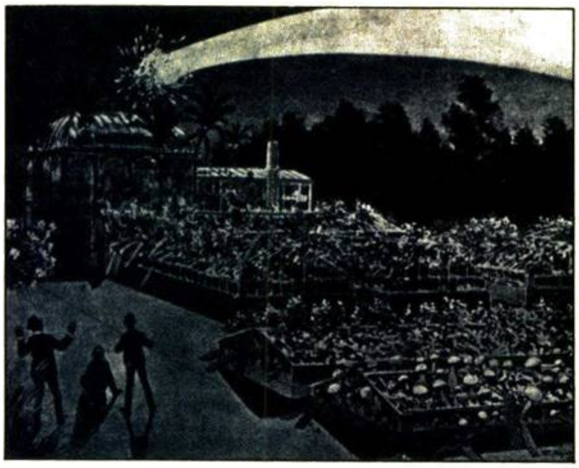
The Influence of Halley's Comet on Plant Growth as it Nears the Earth



From *Florists' Exchange*, April 30, 1910; courtesy Library of Congress.

solely with science — and were kept separate from his other interests. However, on the subject of Halley's comet and the cyanogen in its tail, he seems to have mixed science and fiction thereby inflaming the popular mind.

Datelined May 17, this article describes the fear at its greatest pitch in one city:

Chicago Is Terrified
Women Are Stopping Up
Doors and Windows
to Keep Out Cyanogen

Special to the *New York Times*.

Chicago, May 17 — Terror occasioned by the near approach of Halley's comet has seized hold of a large part of the population of Chicago. Especially has the feminine portion succumbed. All else is forgotten. Comets and their ways and habits have been the principal topic discussed in the streets, cars, and elevated trains today.

Telephones in the newspaper offices have been busy all day with inquiries as to the latest developments in the foreign visitor to the heavens. The principal fear is not that the comet will strike the Earth, but that the gas which is supposed to make up the tail will wipe out all life.

"I have stopped all the windows and doors in my flat to keep the gas out," said one woman over the telephone. "All the other women in the building think it is a good thing, and all are doing the same. Do you think it will keep out the gas?"

Physicians say that there were scores of calls today for their services from women who were suffering from hysteria following the reading of the possibilities of danger from collision or from the dreaded gas.

"My patients say that they are nervous and are suffering from a feeling of depression," said one doctor this afternoon. "They add that they have been reading about the comet and I know that they are simply frightened."

Others calling over the telephone have asked if it is probable "That we will all die at the same time, if the gas is strong enough!" and, "What is the exact time that the first of the gas will strike Chicago, or will New York get it first!"

The public in 1910 became familiar with Flammarion. His opinions and predictions, reported in the *New York Times, Los Angeles Times Sunday Magazine*, and *Busy Man's Magazine*, were contrary to those of the orthodox scientific community. On the subject of cyanogen in the comet's tail, Flammarion claimed there might be enough to bring life on Earth to an end. Awaiting the Earth's passage through Halley's tail, the world attended with interest the images of fictional terror Flammarion created for the mind's eye. His comments on Halley's Comet for the benefit of the press, either artfully planned or crudely expressed, alternated between scientific data and subtly-cued images of the end of life on Earth.

This odd alternation of voices or intentions was heard again and again. In an article entitled "Halley's Comet and the Fate of Humanity: Some Interesting Prognostications of What May Happen Should the Earth Run into the Tail of Halley's Comet and Become Enveloped in its Poisonous Gases" Flammarion wrote:

"The poisoning of humanity by deleterious gases *is improbable. Doubtless if* (italics mine) the oxygen of the atmosphere combined with the hydrogen of the comet's tail it would mean universal death with short shrift."

Surely the phrase "the poisoning of humanity by deleterious gases" grips the mind far more powerfully than the weak near-negation "is improbable." Similarly, "universal death with short shrift" stirs the imagination deeply, while the conditional "doubtless if" fails to animate sufficient reasoning to overcome the fear of impending death.

Flammarion also predicted that if the supply of nitrogen was reduced by the comet's tail, "the brain of every one of us would experience an unexpected sensation of physical activity and the human race would come to a sudden end in a paroxysm of joy, universal delirium and madness." He also claimed that if the tail contained carbonic oxide there would be a "universal poisoning of the lungs."

Even when providing scientific information about the comet, Flammarion's remarks were colored with the language of the fantastic.

"Bathing in the effluvia of the electric, calorific, luminous radiation of the Sun, it becomes impregnated with its rays, undergoing in its whole being fantastic transformations which lend it prodigious glory, develop it by multiplying, ten times, a hundred times, its volume, lengthening it to millions and millions of kilometers by a kind of phosphorescence which always is extended away from the Sun and gives rise to the formidable tails which filled with terror the souls of our ancestors.

"Therefore the wanderer's path takes it away from the ardent center to sink into the deserts of immensity, gradually diminishing in size, becoming a sort of invisible bubble, and finally to find again the night of its aphelion in which for years and years it is lost to the eyes of astronomers on the Earth. It goes away to a distance of five thousand million kilometers, into the ultra Neptunian night, in which its speed is gradually decreased to less than a kilometer per second."

Flammarion had been working on horror stories about a cometary collision with Earth for a long time. In 1893 and 1894, his story "The End of the World" appeared in a scientific magazine and was later published in book form in Paris. The story tells of the destruction of Earth by a comet. It was translated from French for the *Scrap Book's* May 1910 issue, and was summarized in Edwin Emerson's scare pamphlet *Comet Lore* published that same year. The last pages especially stir the sense of utter doom!

"Already the comet had passed within the lunar orbit. Nearer and nearer it drew to the terrestrial atmosphere. It almost touched the hem of the Earth's robe with its fiery fingers now.

"Then the contact came. There was a flash on the horizon. A great sea of colored flame shot up. From a myriad throats came an agonized wail:

'The world is on fire! The world is on fire!'

"It was the last sound that came from a human throat. Every man, woman, and child perished as swiftly

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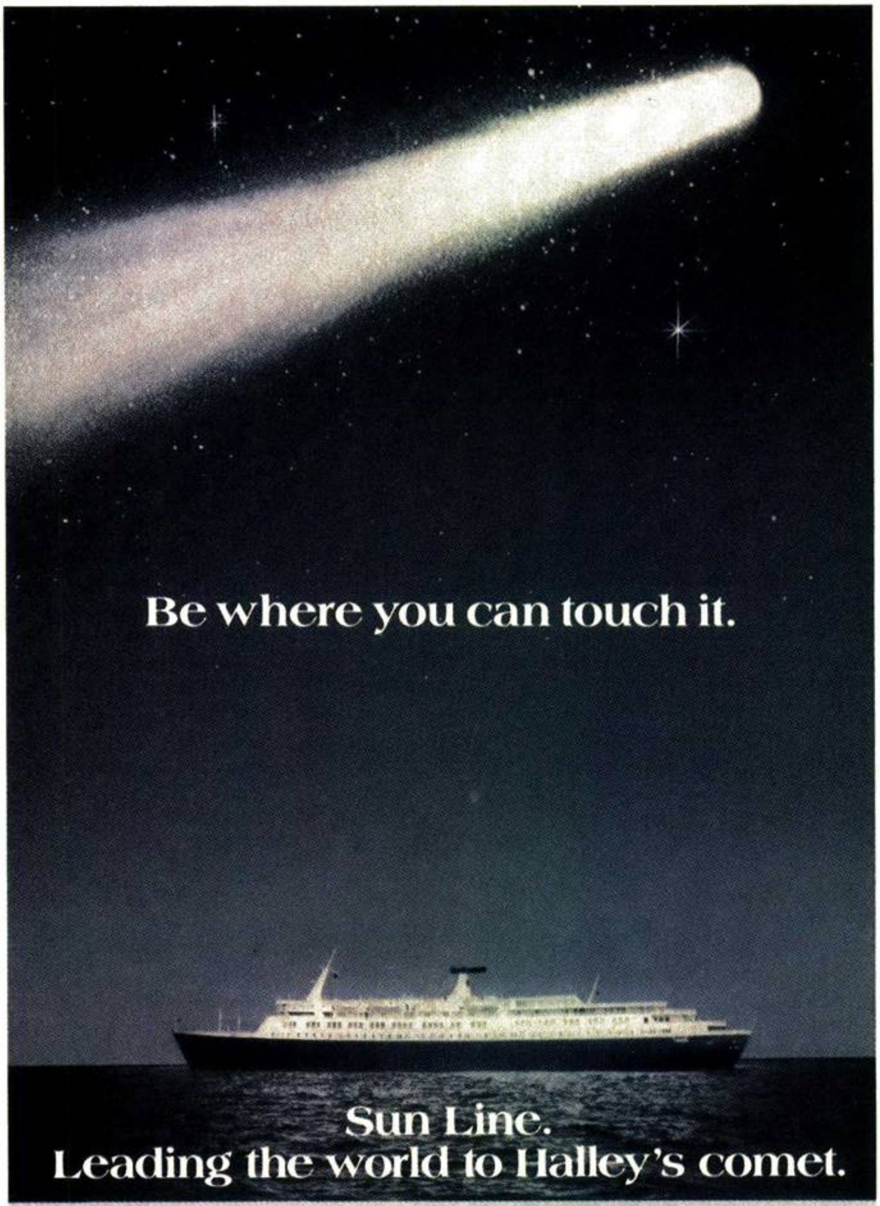
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as if a mighty wind had blown out their lives like so many candles.

"A few seconds elapsed before the nucleus struck the Earth. In those few seconds the atmosphere was ignited with a terrific explosion, and the Earth was wrapped in a tossing, roaring, seething garment of flame. Rivers and lakes disappeared in hissing clouds of steam. Forests and cities flared up like matchwood. Then came the crash.

"Like a great celestial projectile the solid nucleus of the comet pierced the egg-shell crust of the Earth and buried itself in the semimolten interior. The comet tore its way on like a shot piercing the boiler of a battle-ship.

"The Earth was immediately converted into a planetary volcano. Oceans were spilled like thimbles of water, only to disappear in dense clouds of vapor which mingled with the fiery contents of the Earth. Continents were twisted and torn like paper.

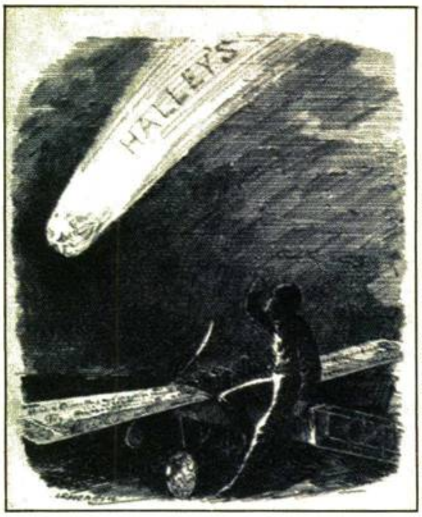
"Rocks disappeared in that fearful heat and became like water. The Earth seemed to reel as it was smitten by that mighty blow. A great rent appeared which extended from pole to pole, a planetary chasm out of which spouted geysers of molten rock, jets of flaming gas, great sprays of matter which were hurled out for miles into the blazing atmosphere, only to drop back in a great rain of fiery heat.

"There was a vast indentation produced by the collision which was quickly inundated by this sea of fluid matter. Mountains disappeared like cakes of ice in pots of boiling water.

"Once more the world was reduced to the ball of incandescent liquid and gas from which it had painfully evolved into a living globe through millions and millions of years. It shone like a little Sun in the black canopy of the heavens, brilliantly self-luminous. For thousands of years, perhaps for millions, it was doomed to wander through space, a rock-bound, sea-swept world reduced to the pitiful condition of a globular furnace in which the beginning of a new life was being forged. Its dull-red glow for ages bore testimony for more fortunate planets to the frightful cataclysm through which it had passed."

The American press portrayed Flammarion's personal behavior and character as being of a piece with his horrific predictions. By an account in the *Los Angeles Times*, Flammarion was "The greatest living astronomer of France." Against a photograph of Flammarion standing beside a globe showing zodiacal figures, the article discloses these two anecdotes about the astronomer:

"Mme. Flammarion is devoted to her husband. She refused to allow any barber to cut the complicated locks of her "Flamme" as she calls him. She cuts his hair herself and then stuffs her footstools and furniture with it."



From *Punch*, May 25, 1910; courtesy Library of Congress.

The Great Amateur
Aviator: "Marvelous flier! And does it for love!"

The second anecdote disclosed that a visitor to his observatory, a lady of "fair shoulders" wearing an evening gown, once stood between Flammarion's telescope and the astronomer. "Flammarion immediately permitted himself a gallant compliment upon this charming barrier between the stars and himself." The lady was so gratified by the compliment that she "left him her skin in her will to bind a book. A copy of one of his own works may be seen, bound in human skin, upon his table."

Needless to say, scientific astronomers were outraged by Flammarion's fear-mongering. Like the Mercury Theatre's famous "War of the Worlds" Hallowe'en radio treat in 1938, Flammarion's pronouncements stirred up profound fear and ill-feeling. He was severely criticized in the scientific press. In a letter to the editor of the *English Mechanic and World of Science*, Felex de Roy chastised Flammarion.

"The real signification of the astronomical event we now have the pleasure to witness has been completely and very badly denatured in the public's spirit here, under the influence of a small band of pseudo-scientists living in France. As soon as the fact of a probable transit of the Earth through the tail had been announced, a dreadful story of 'poisoned cyanide gases' went out, and expanded with a wonderful ease. This 'fin du monde' story has found very firm believers . . . .

"What I wish to point out is . . . that the fears of the comet were *not* aroused by this celestial body *itself*, but by 'a tale of how certain Frankish astronomers had foretold the destruction of the Earth.' When one considers that the publication of this tale induced many people in France, Spain, Italy, Hungary, etc. to commit suicide, may the author of this story not be considered as a public malefactor?"

The letter's author went on to discuss the written sources that would reveal the story's originator and also discussed the obligation of science to facilitate "the gropings of mankind," not hamper them.

Flammarion was also extremely practical and far more shrewd than other astronomers. He endorsed a brand of excellent binoculars in ads which appeared in the better French and Italian picture magazines during the months and weeks before the comet's appearance. The binoculars sold widely and Flammarion thereby became perhaps the only astronomer to profit financially from Halley's 1910 apparition.

Among the astronomers who were in the public eye during the days of the comet, Flammarion filled a unique niche. With talk of hair-stuffed furniture and a book bound in human skin, Flammarion came to represent the ancient past — the scientist's ancestry associated with the art of reading signs in the heavens. He brought the art to its inevitable conclusion, the meeting of the celestial and the mundane in an apocalyptic cataclysm.

From today's point of view Camille Flammarion, flamboyant astronomer, brought a touch of the Night, the old ways of seeing back to mind, recalling one branch of astronomy's heritage.

Jerred Metz
St. Louis, MO

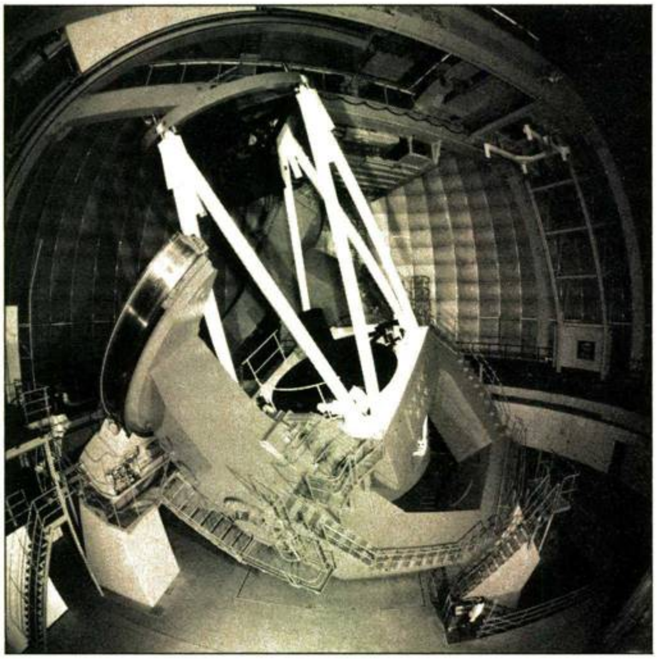
Dark Skies for Comet Halley

Once and only once in most human lives, there comes the time of Halley's Comet. No object in the sky is so historic. This comet links generations and generations of humanity in a chain of wonder. Children who see the great comet in the heavens will remember and, if they survive to old age, can recall for their own grandchildren the excitement of that time and the majesty of that sight.

Now the occasion is again at hand. The comet, last seen when Model T Fords chugged on dirt roads and the earliest fragile airplanes first took flight, is almost within range of backyard telescopes and will soon grow into full radiance. Millions are expecting to have an experience worthy to pass on to grandchildren or great-grandchildren.

This time, however, our hopes may be cheated. Ours could be the first generation in history to miss the

A special astronomical project by one company – The 3.5 m telescope from Zeiss



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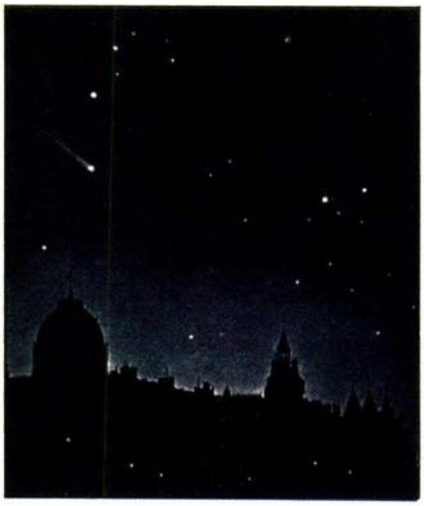
comet's glowing head and million-mile-long tail spreading across large sections of sky. This time, in fact, the chain of wonder may be broken: many of us will see no comet at all, unless we take action.

Back in the spring of 1981, I started writing to people about the idea of "Dark Skies for Comet Halley" — DSCH for short. The goal was twofold. First, I wanted to achieve at least some dimming of outdoor lighting for the best nights of Halley in 1986. Second, and even more importantly, I wanted to bring the problem of light pollution to widespread public attention. Perhaps then we could get started on reforming the outdoor lighting laws and practices which are threatening all of astronomy.

It's really a battle of awareness — a contest between the most famous of all celestial visitors and a lack of public awareness which is robbing us blind — quite literally. We are having stolen from us a natural sight which has inspired not just the scientist in us, but our very hearts. What price should we set on something so precious?

The past four years' efforts have shown that awareness of light pollution — getting people's attention — is far more than half the struggle. By the time you read this, booklets on outdoor lighting and light pollution from both the Astronomical League and Dr. David Crawford of Kitt Peak National Observatory should be ready for distribution. Crawford's is a reference work and guide for dark-sky activists; the League's will grab local legislators' interest because it focuses on the tremendous savings for municipalities. Will this effort really have any effect? Well, consider some of the developments in dark-sky legislation during the past few years:

People all over North America *are* interested in learning that there is a threat to Halley's Comet. *Science '82* ran an article on Dark Skies for Comet Halley which attracted the interest of many large radio stations and newspapers in the U.S. and Canada. The same followed a front-page article in, of all places, *The Wall Street Journal*. Baltimore, Spokane, Oklahoma City, Edmonton, and many other cities got to hear about outdoor lighting waste and things that can reduce it.


From *l'Illustration*, May 28, 1910; courtesy Library of Congress

But not just newspapers and astronomers are interested in light pollution. In New Jersey (perhaps the most light-polluted state in the nation), State Senator and Assistant Minority Leader James R. Hurley has proposed a "Dark Skies" bill. This bill will have the state government recommend that all municipalities in the state have some kind of Halley light-dimming program and, more importantly, *require* that every municipality receive an information package on not just Halley's Comet and light pollution, but on outdoor lighting reform as well. Such bills move slowly, but this past spring it passed the New Jersey State Senate unanimously and is expected to complete the process and become law, perhaps by the time you read this.

The victories for dark-sky legislation in Arizona and California are also very impressive. More recently, East Brunswick, New Jersey a city of about 40,000 people, removed hundreds of streetlights and shielded other lights to prevent light being shed above the horizon. Lighting curfews at 11 p.m. have helped reduce by more than 30% the skyglow in Flagstaff, Arizona. Much more remains to be done everywhere, of course, but these developments are significant steps against light pollution and hold promise for more action in the near future.

The League wants to expand greatly its anti-light pollution activities and aid member clubs in their efforts to reduce local lighting waste. I'm aiming to unite many previously isolated dark-sky activists and their talents, forces, and knowledge. Let's hope we can do that by the time Halley departs for another lifetime.

You can purchase a subscription to the 1985 and 1986 issues of *DSCH Journal* for $8.00 ($10.00 outside the U.S.), made payable to the Astronomical League. You get a total of 96 pages, including the League's newsletter, *The Reflector*. To receive the *DSCH Journal* and information on the Crawford and Astronomical League light pollution booklets, write to Don Archer, Executive Secretary, Astronomical League, P.O. Box 12821, Tucson, AZ 85732.

This, however, is the only Halley visit we're going to see. We cannot run away to what is left of dark country — or to LPR filters — or to increasingly large telescopes — forever. We owe it to ourselves and especially to children — who deserve a chance to be inspired by the wonder of a dark nighttime sky — to do all we can to preserve this priceless natural resource.

Fred Schaaf
Millville, NJ

The Lost Stars of James South

When it comes to your telescope, do you insist on perfection? Do you compare its performance with that of other scopes, or hunt down ghostly nebulae and try to split nearly impossible doubles just to test its capabilities? If so, you are not very different from most amateur astronomers. They tend to be a meticulous lot — and they must be.

Usually such dedication to excellence brings rewards in the form of personal achievement and satisfaction. Occasionally it brings fame. But when carried to extremes, it can be disastrous. The names Herschel, Lord Rosse, Admiral Smyth, and Webb may sound familiar, but have you ever heard of James South? Probably not. Yet by 1829, he had completed a series of important observations and stood ready to pioneer a new branch of astronomy. It was a rare opportunity and the fame that was sure to follow was within his grasp. But it all eluded him — just because of his uncompromising demand for perfection.

Before his downfall, South enjoyed a remarkably successful life. He was born in London in 1785 and became interested in astronomy at a young age. He went on to study surgery and earned an enviable reputation in that profession. In 1820, he helped found the Astronomical Society of London and was elected a Fellow of the Royal Society one year later.

From *Illustrated London News*, May 28, 1910; courtesy Library of Congress

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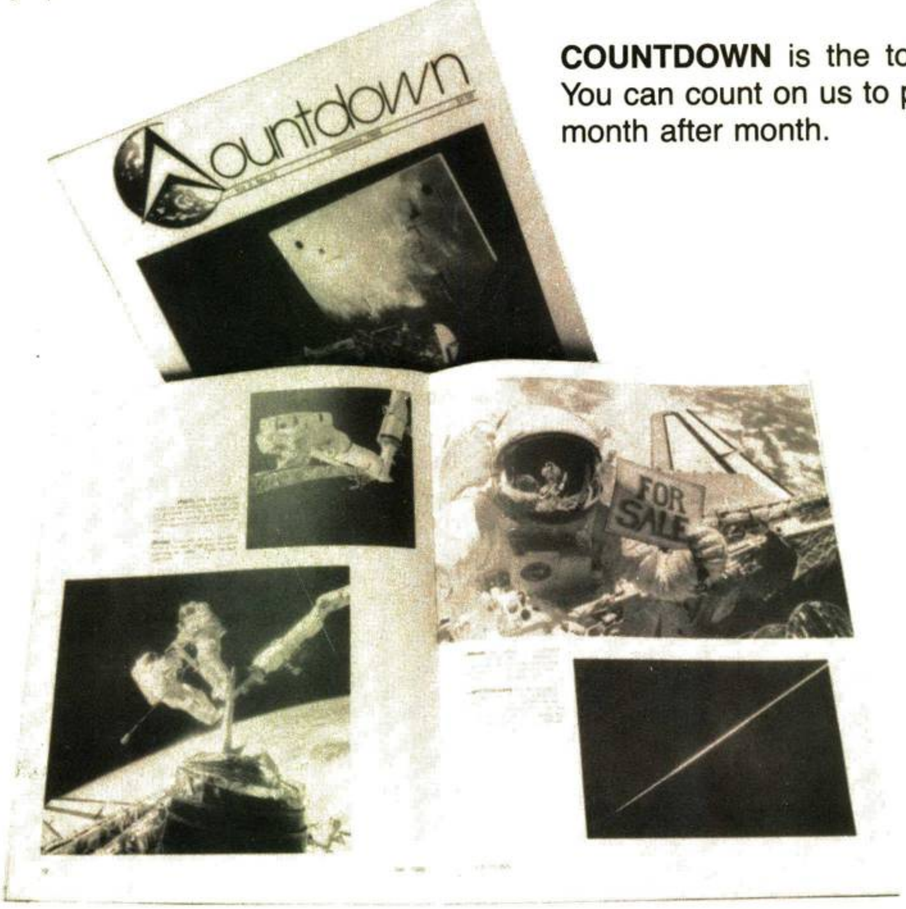

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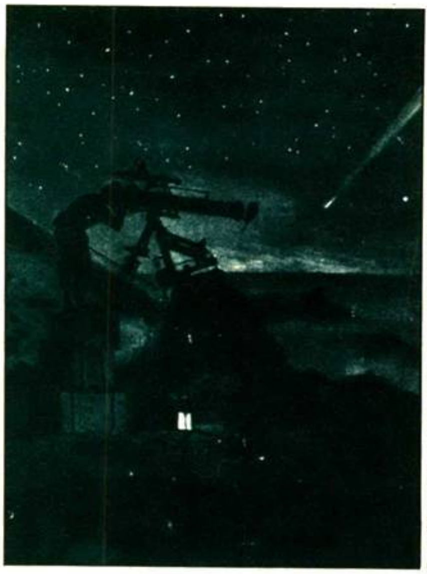
South's career in astronomy began in 1816 when he married a woman of considerable wealth, enabling him to indulge in his lifelong passion for observing. He gave up his surgical practice and built an observatory equipped with three superb telescopes. One of these was a refractor with an aperture of 3.75 inches, a focal length of five feet, and an equatorial mounting so rigid that star images were unaffected by heavy nearby traffic. His second equatorial was a 5-inch refractor with an objective made by Charles Tulley. South judged that the instrument's performance at high powers was unsurpassed by any refractor in existence. But his most prized possession was a 4-inch transit instrument built for South by Edward Troughton, an instrument maker who considered it his finest work.

Double stars were of particular interest to South. He had observed many of those charted by William Herschel and was convinced that important work needed to be done in this field. Until that time, most telescopes had poor mountings and were operable only at low power. South believed that if solidly mounted and capable of high magnifications, modest-sized instruments could reach most of the stars listed in Herschel's catalogues.

An unresolved question during that era was whether double stars were gravitationally-bound stellar systems or merely chance alignments of random stars. Between 1779 and 1784, William Herschel observed and catalogued 702 multiple stars. When he reobserved them 20 years later, Herschel found a number of changes that suggested they might indeed be binary systems. But the crude measuring devices he used in his early observations, together with the experimental nature of his first measurements, combined to make these results unreliable and further verification was needed. However, no systematic follow-up was made until John Herschel began a re-examination of his father's measurements in 1816.

About that time, South was considering a similar program. By using more precise instruments and techniques than those available to the elder Herschel, South hoped to compile a catalogue of multiple stars confirming the suspected changes in their positions. His two equatorials were ideally suited to such an undertaking and at his suggestion, John Herschel joined him in the project.

The result of their efforts was a landmark catalogue of 380 stars — published in the *Philosophical Transactions of the Royal Society* in 1825 — which conclusively proved that double stars did in fact orbit each other.



From *l'Illustration*, June 11, 1910; courtesy Library of Congress.

After completing the catalogue, South began searching for a site where he could continue his work on double stars free from the soot and smoke of London. He eventually moved to Passy, France in the autumn of 1824 and observed there until the end of 1825. In that short time, South measured 458 multiple stars — more than a third of them never before measured.

South returned to England and presented his catalogue of 458 stars to the Royal Society. For that, along with a paper on solar transit timings, South was awarded the Royal Society's prestigious Copley medal in 1826.

Now at the height of his career and eager to further his work, South began construction of a new observatory in Campden Hill, Kensington, England. It was to be one of the most magnificent private observatories ever built.

Intending to extend his double star observations to even fainter magnitudes, South was determined to acquire the largest telescope possible for his new observatory. He purchased an 11.75-inch lens — the second largest in the world at that time — and had the mount built by Troughton.

For a while, South's successes continued. As President of the Astronomical Society of London, he presided over a committee set up to recommend ways of improving the *Nautical Almanac* and petitioned for a royal charter which led to the Society's incorporation in 1831. That same year, he was knighted by King William IV and awarded an annual pension for his contributions to astronomy. That year also marked the beginning of the end of his career.

It began with Troughton's equatorial, which was — in South's view — a failure. Even before the mount was completed, several of South's friends pointed out that its design was inadequate for such a large lens, but South's faith in Troughton was absolute. The instrument maker attempted to correct the mount's shakiness, but unsuccessfully. That, together with South's unreasonable demands, caused a bitter dispute between the two. South refused to pay for the mount and Troughton took legal action against him.

The court proceedings that followed dragged on nearly five years. The emotional toll on South was devastating. When the judgment went against him, he was furious. In a rage, South publicly demolished the equatorial (fortunately sparing the objective) and sold the wreckage as scrap metal.

South never recovered from the episode. He lost a sizable fortune, his friendship with Troughton, and very nearly his sanity. Several years before, in a disagreement over the tenure of the presidency, he had withdrawn from the newly-chartered Royal Astronomical Society of London and in a separate incident had published an angry attack on the Royal Society. His quarrel with Troughton only alienated him further from his colleagues.

Scarcely a decade after he and Herschel had begun their catalogue, South's productive years were over. Instead of making his comprehensive survey of multiple stars, he worked mostly with meridian instruments. He also devoted much time to studying clocks and the movement of pendulums in a vacuum. In 1846, he experimented with the effects of passing trains upon star images reflected in liquid mercury. The lens in which he had placed so much hope lay idle for 30 years.

Meanwhile, others pursued the stars that South had lost. In 1837, John Herschel surveyed the southern skies at the Cape of Good Hope while Friedrich G.W. Struve published his monumental catalogue; his *Pulkovo Catalogue*, completed by Struve's son Otto, followed in 1850. It was also during this time that Admiral William Smyth prepared his famous *Cycle of Celestial Objects*.

During the 30 years that the 11.75-inch lens was owned by South, he made only one discovery — the sixth star in the Trapezium — and that is credited to John Herschel.

As if the loss of three decades and the stars that he might have claimed was not punishment enough for an intense and obsessive temperament, South's last years were plagued by partial deafness, near-total blindness, and much physical suffering. In 1862, he donated the 11.75-inch lens to the Trinity College observatory in Dublin, Ireland. South died at Campden Hill in 1867.

Edmund Fortier
Cohasset, MA

Cometa
Halley

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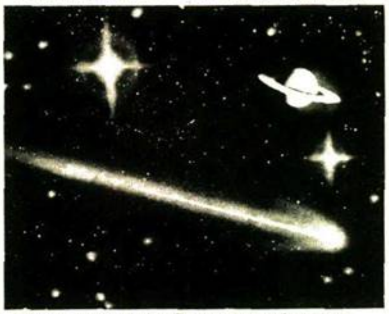

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Hot Tub Astronomy: A Guide for the "Wet Astronomer"

Here we are! Your new astronomers. A group that grows larger every night. To the world of fantastic amateurs and brilliant professionals, comes the new breed — the Wet Ones!

We consist mainly of people, who if you say "east" automatically look left. It used to be we only looked up to see if it was going to rain. Now, wet and warm in our outdoor hot tubs, we have discovered the sky.

It's a discovery that is absolutely inevitable. I wish I had known about it before installing the hot tub. Hot tubs are extremely difficult to relocate.

Perhaps, we can get a warning printed by, oh, NASA or somebody, and have it attached to newly manufactured tubs: "WARNING! SITTING IN THE HOT TUB AT NIGHT MAY LEAD TO AN ADDICTION TO SKY WATCHING. USE EXTREME CAUTION IN PLACING THIS TUB SO OBSTRUCTIONS TO THE SKY WILL NOT FRUSTRATE YOU."

In any case, the hot tub astronomer will, of necessity, become a specialist. Concentrating only on that part of the sky that passes through his own view from the hot tub, the rest of the heavens will remain in Siberia as far as he is concerned.

People jump into hot tubs for a variety of reasons therapeutic and social. A survey at the local Spa Shop revealed a host of replies.

Question: "Why are you buying a hot tub?"

Answers: "For my arthritis."

"The neighbors have one."

"To attract chicks."

"Why not?"

In short, not one person interviewed said, "To become an astronomer."

Little do they know the fate that awaits them. Soon they will be checking out the prices of better binoculars, only to buy a telescope instead.

"If only I had known!" they will lament. "I would have put the Jacuzzi over there," pointing to an open space in the yard now occupied by the dog house.

Wet astronomers everywhere: you can help. Take this issue of ASTRONOMY magazine to the owner of the nearest Spa Shop in your neighborhood. He can get it to those who need it most.

Here is a list of things new spa owners will need to know:

1. LOCATION: Don't place the tub where you can see it from the house. Put it where you can see the sky from the tub. The dog would probably like the spot in the shade of the eaves better, anyway.

2. LIGHTING: The less the better. Walk around at night when working on Rule 1. That is your last chance to have the big shade tree stand between you and the street light on the corner.

3. HEIGHT: Don't sink the tub down level with the ground, the way you would a swimming pool. You will want the seat to be about chair high. This allows you to be a decent height for looking through a telescope. And, it is very difficult to have a conversation with people out of the tub, if you are talking to their ankles.

4. DECORATION: The decorators have designed an array of cute little lattice buildings to put over and around the spa.

We fell for one with an adorable gazebo look. Since we got it, we've removed so many slats, in order to see out, that it looks as if a tornado came through. A decorative wall can be very handy, though, if you plan it right. Use it to block undesirable light and to keep supplies high and dry.

5. FURNITURE: Allow room for a patio table on each side of the tub. (Or have two built on.) You already knew you would need one. For partying. A place for the food and drinks.

What you may not know is that as you relax with your favorite beverage and enjoy the warmth of the bubbling water, your body will float down, your head will lean back, and you will be looking at the sky.

At first you will just see it and enjoy its magnificent beauty. Later, you will begin to see it, really see it. Those things, in your view, will become familiar. But, how can you become familiar with something, when you don't know its name?

So you need a second table for your supplies. Don't put them on the food table where they can be spilled upon.

6. SUPPLIES: How can you find out the name of your very special star? Or is it a planet?

When you can't find enough information in your home, there's your local library and every big shopping center has a book store.

At either of these places you will be exposed to ASTRONOMY magazine. I loved it for its beautiful pictures, but we became addicted to it, for its monthly information about what's out there, right now! This month! That is, after all, what you really want to know. There is a section in ASTRONOMY magazine that advertises other things you may decide you need. I don't mean to make this sound like a commercial for them, but how else can I tell you that we sent for a Planet Chart that has come in very handy.

The rest of the things — towels, flashlights, binoculars, a pencil and notebook — you can decide for yourself.

7. FRIENDS: Our hot tub faces south and we are able to get a full view of the ecliptic (look that up, you'll want to know) and south to the ocean. We were just lucky, I guess. But our friends, with a full north view, say they were very lucky. They think the north is the best for a variety of reasons.

However, if you look south, a friend who looks north can be very handy. First, he is happy to tell you about stars you haven't even heard about. And you get to show off and tell him some things about the south side sky. And I could tell you some interesting things about the view south. Maybe next time I will.

Beverly Mosier
Laguna Beach, CA

A Paean to Hot Tub Astronomy

The Jacuzzi is hot and bubbling, the glasses cold and full.
No matter what the weather is, it's time to jump in the pool.
First we sit and visit, then relax and look at the sky.
The stars are twinkling everywhere, and we begin to wonder why.

We get up in the morning early, so we can run the length of the park.
Have our coffee and toast in the hot tub, while the sky above is dark.
Now the East glows pink with the sunrise, a star shines brightly there, too.
We're sure it's our planet, Venus, but we don't know how we knew.

What's that other little star there, that gleams so faintly below?
We'll have to put a book out here, to learn what we want to know.
While real astronomers stand in the cold, parkas tied up snug.
Hot tub astronomers float in the tub, warm as bugs in a rug.

Thank you professionals and amateurs avid, our gratitude you have earned.
You worked, so we could sit and read, all that you have learned.

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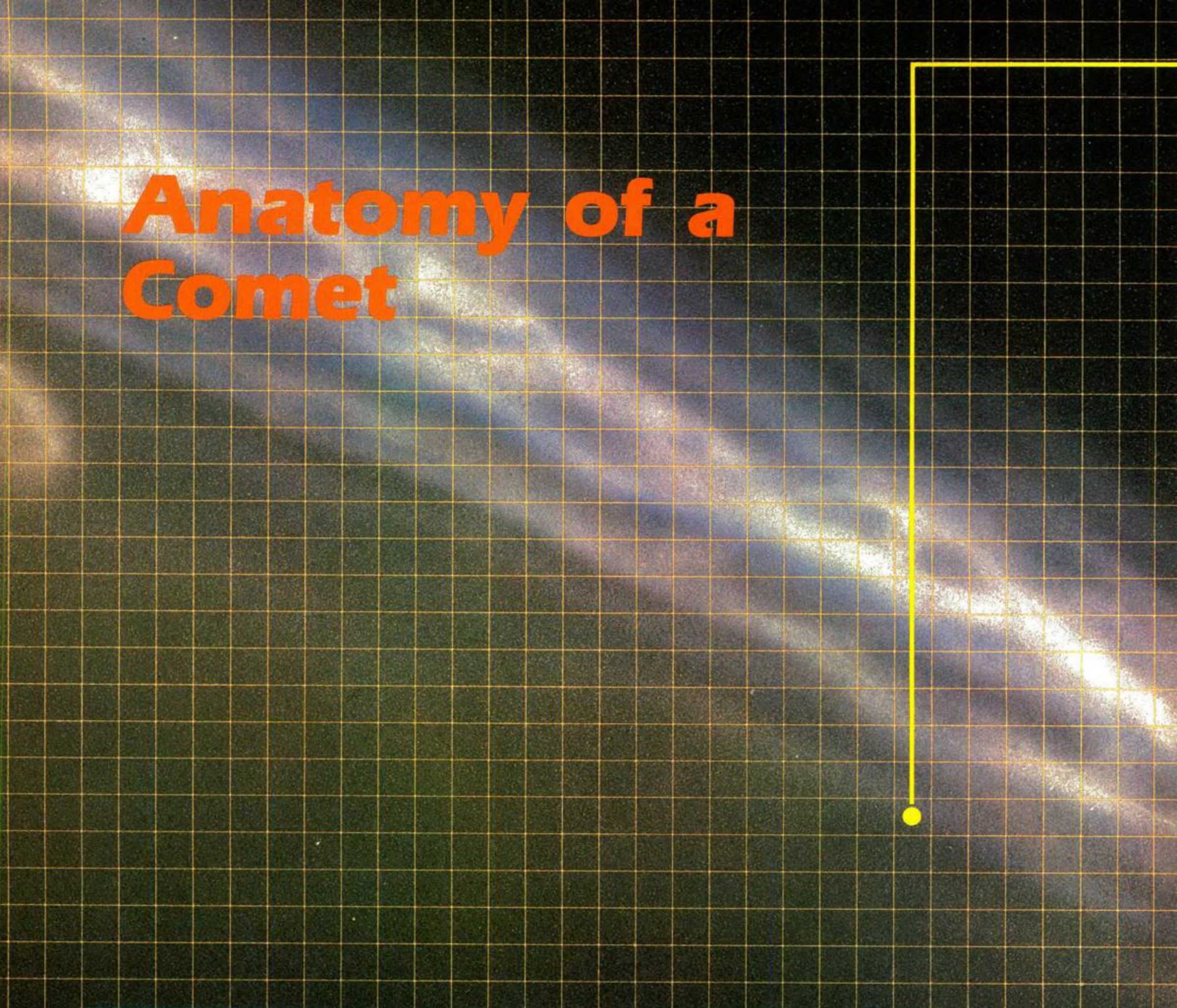
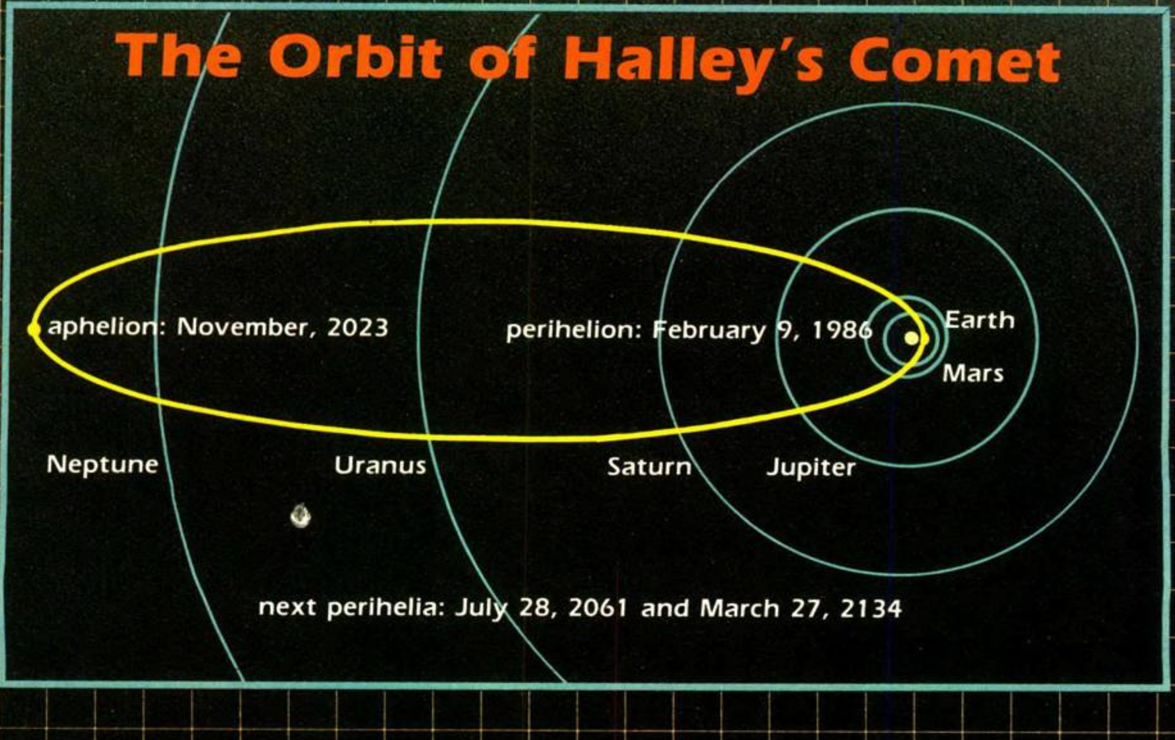
Anatomy of a Comet

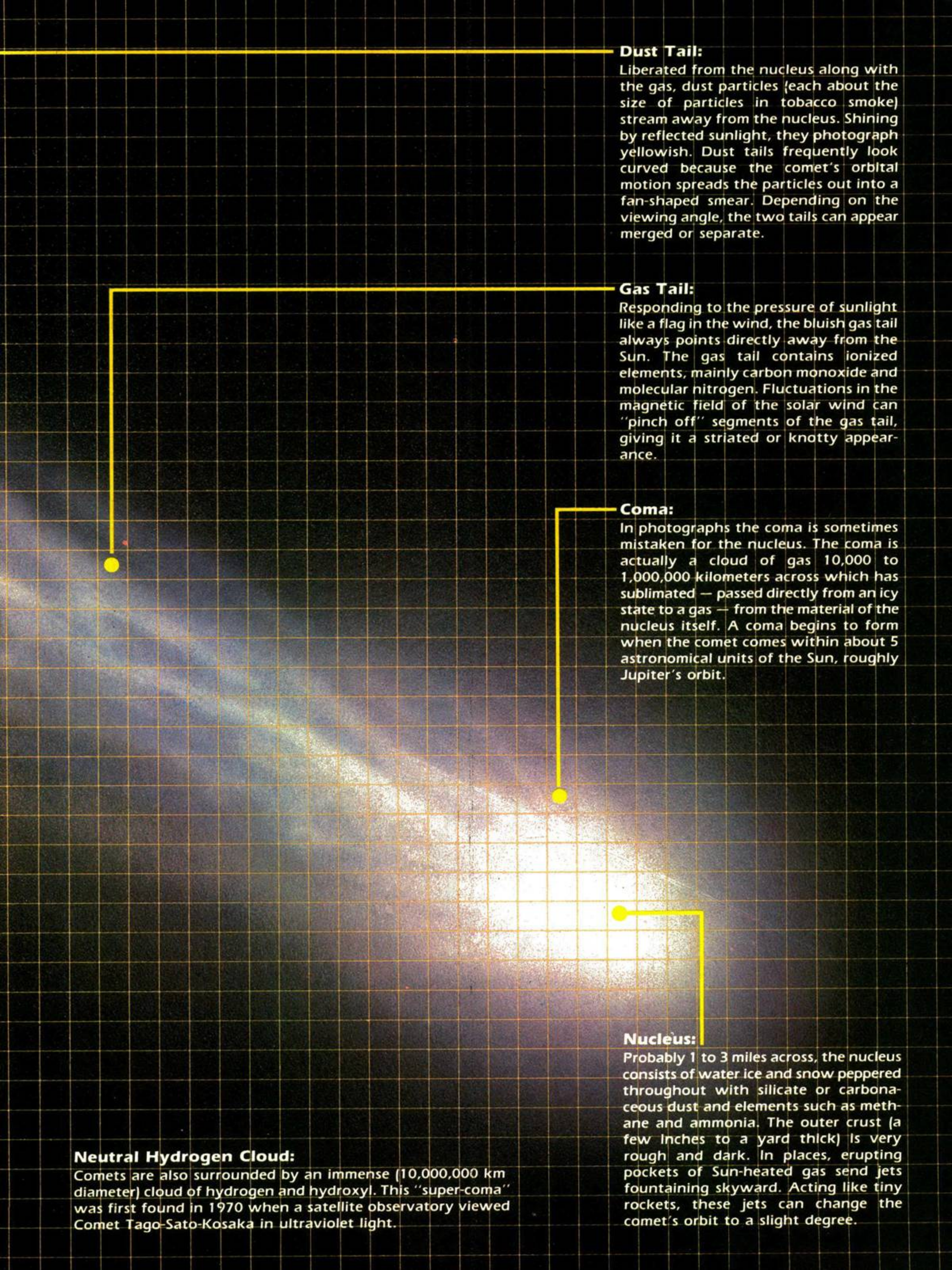




The Orbit of Halley's Comet

aphelion: November, 2023
perihelion: February 9, 1986
Earth
Mars
Neptune
Uranus
Saturn
Jupiter

next perihelia: July 28, 2061 and March 27, 2134



Dust Tail:
Liberated from the nucleus along with the gas, dust particles (each about the size of particles in tobacco smoke) stream away from the nucleus. Shining by reflected sunlight, they photograph yellowish. Dust tails frequently look curved because the comet's orbital motion spreads the particles out into a fan-shaped smear. Depending on the viewing angle, the two tails can appear merged or separate.

Gas Tail:
Responding to the pressure of sunlight like a flag in the wind, the bluish gas tail always points directly away from the Sun. The gas tail contains ionized elements, mainly carbon monoxide and molecular nitrogen. Fluctuations in the magnetic field of the solar wind can ''pinch off'' segments of the gas tail, giving it a striated or knotty appearance.

Coma:
In photographs the coma is sometimes mistaken for the nucleus. The coma is actually a cloud of gas 10,000 to 1,000,000 kilometers across which has sublimated — passed directly from an icy state to a gas — from the material of the nucleus itself. A coma begins to form when the comet comes within about 5 astronomical units of the Sun, roughly Jupiter's orbit.

Nucleus:
Probably 1 to 3 miles across, the nucleus consists of water ice and snow peppered throughout with silicate or carbonaceous dust and elements such as methane and ammonia. The outer crust (a few inches to a yard thick) is very rough and dark. In places, erupting pockets of Sun-heated gas send jets fountaining skyward. Acting like tiny rockets, these jets can change the comet's orbit to a slight degree.

Neutral Hydrogen Cloud:
Comets are also surrounded by an immense (10,000,000 km diameter) cloud of hydrogen and hydroxyl. This ''super-coma'' was first found in 1970 when a satellite observatory viewed Comet Tago-Sato-Kosaka in ultraviolet light.

Why wait for your telescope?

We have over 300 in stock!

In this year of Halley's Comet, with over-worked manufacturers now taking as long as six months to fill telescope orders, no dealer can guarantee immediate shipment on every telescope. But, with more than 300 telescopes in stock — and 600 more on the way — you've got a better chance at getting immediate shipment from Ad-Libs Astronomics than from virtually any other dealer.

Why buy your scope from us? Here are four good reasons . . .

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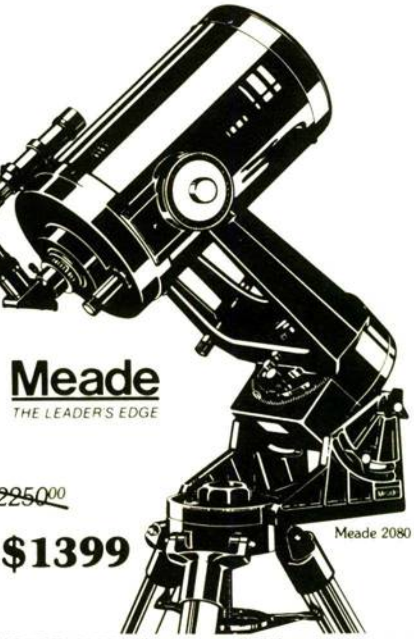
- **We give you all manufacturers' accessories.** We don't strip our telescopes of finders, cases, and eyepieces so we can show an artificially-low selling price. We have only factory-fresh telescopes, complete with *every* part the manufacturer supplies.

- **We have low prices and free freight.** Our discount prices save you up to 40%. And, unlike some dealers, we don't add unexpected and inflated freight charges to the price of a scope. The price you see is the price you pay.

- **We're experienced.** Some dealers have popped up lately to make a quick buck on Comet Halley, only to fade away again as the comet does. Their clerks don't know much about telescopes or the accessories you need to get the most out of your scope, and that can cost you money. We've been helping amateur astronomers pick the right scopes and accessories for over six years. We can help you, too. And, unlike some dealers, we'll still be around to give you good, unbiased advice and save you money even after the comet goes.

So, do yourself a favor. Take all telescope advertising with a grain of salt — even ours. If a deal looks too good to be true, it probably is. Before you order *any* telescope through the mails, check out the reputation of the dealer with someone who has bought from them in the past, or call the manufacturer and see what he has to say about the dealer. A little checking ahead of time can save you from making a costly mistake.



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MEADE 2080/LX2: premium LX (Long eXposure) drive and Research Grade visual accessories make this 8" scope ideal for the advanced amateur astronomer, particularly if serious deep space photography is in the cards. Complete with fork mount, wedge, adjustable height tripod, high transmission optical coatings, no-tool knob set, deluxe latitude adjuster, 8 x 50mm finder, 7mm (286x) Research orthoscopic & 20mm (100x) Research Erfle 1¼" eyepieces, ultra-precise electric LX worm gear drive, setting circles and manual slow motion controls in both axes, dust cover, star diagonal and visual back, power cord, instruction manual, foam-lined case, and *lifetime* warranty. 10 in stock. $2450 list, for **$1599!**

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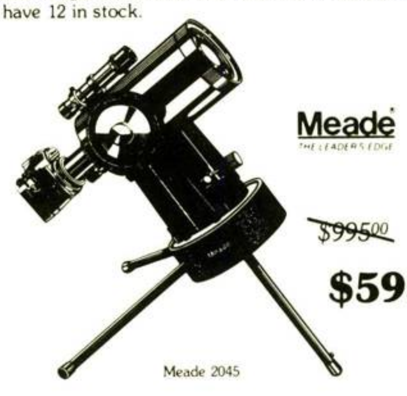

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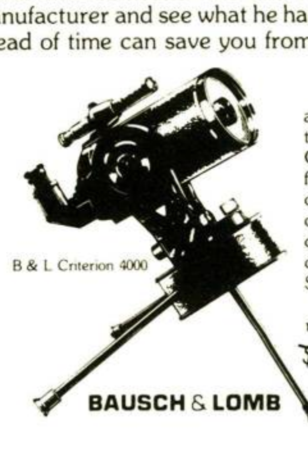

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B & L Criterion 4000: a great value in complete small aperture telescopes that can be used as an astronomical telescope, a telephoto lens, or as a terrestrial spotting scope. Complete with fork mount, tabletop tripod legs, 4 x 15mm finder, 30mm (40x) & 18mm (67x) 1¼" symmetrical eyepieces, high transmission optical coatings, electric drive, setting circles and manual slow motion controls in both axes, dust cover, star diagonal/visual back, power cord, fitted carrying case, instruction manual, and *lifetime* warranty. 25 in stock. $695 list, for only **$519!**

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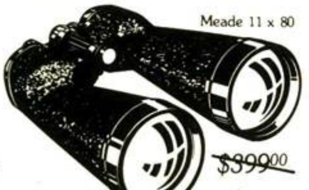
As shown, with optional dual axis hand controller and declination motor, the 2080/LX3 is only $2144!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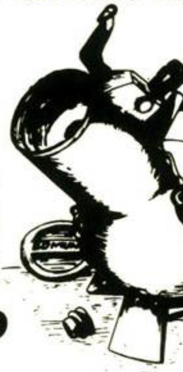
~~$299.00~~ **$239**


Edmund Astroscan

Free Telescope and Accessory Discount Price List

We are authorized dealers for Meade, Celestron, Questar, TeleVue, Lumicon, Coulter, Bausch & Lomb Criterion, Edmund, University Optics, Olympus, Telrad, JSO, Vernonscope — and more! Send a stamped, self-addressed envelope for our *free* discount price list showing your savings on the hundreds of telescopes and accessories we carry — or send $1 for our complete catalog — the most detailed and informative catalog available, according to our customers. It's a catalog that takes the guesswork out of picking the right telescope and accessories, and saves you money, too!

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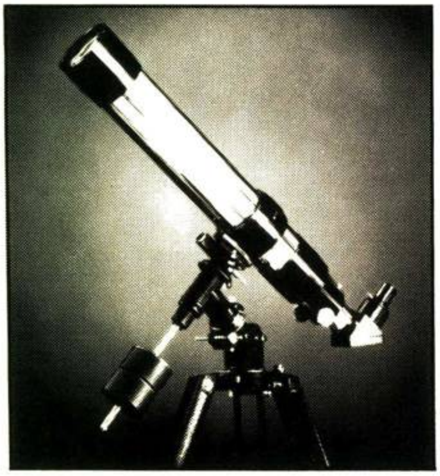
TeleVue Renaissance

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w/mount

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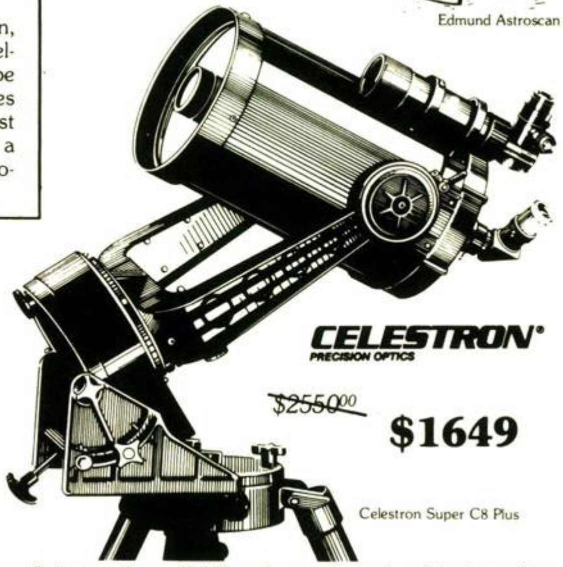
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Space Probes to Comet Halley

Novosti photo

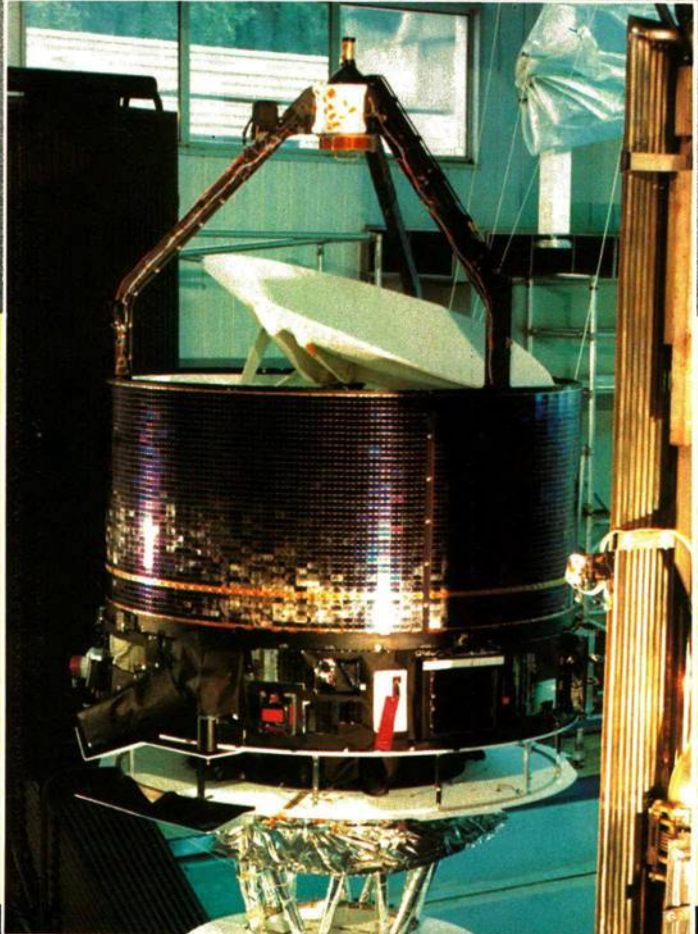
This apparition of Halley's Comet is a very special one for scientists — for the first time, they'll be able to study a comet up close. From Earth, astronomers 'round the world will monitor Halley using photometry, astrometry, spectroscopy, and filtered photography to examine every possible detail of a real live "dirty snowball" as it swings by the Sun. Yet the real thrill for scientists won't come from Earthbound observations, but from five spacecraft expected to rendezvous with Halley's Comet during March 1986.

Vega

The Soviet Union has sent two probes to study Halley's Comet. Vega 1 — launched December 15, 1984 — will pass within 10,000 kilometers of Halley's nucleus on March 6, 1986. Vega 2 — launched December 21, 1984 — will also move within 10,000 kilometers of the nucleus some three days after Vega 1's encounter. Both craft carry narrow and wide-angle cameras, a spectrometer, and a camera/spectrograph. Their objectives include photographing the coma, taking infrared spectra and images of the nucleus, and studying the nature of the coma's dust and plasma particles and the magnetic phenomena involved.

Giotto

The European Space Agency's probe is called Giotto, after the Italian artist who painted Halley's Comet in a fresco in 1303-1306. Launched on July 2, 1985, Giotto will have the distinction of being the only space probe to move deep into the comet, passing only 500 kilometers from the nucleus on March 13, 1986. From inside the coma, Giotto may provide the only actual four-color images of the comet's nucleus. The craft will also sample material in the coma using dust detectors and a mass spectrometer, and conduct magnetic experiments using magnetometers. As it will move at 68 kilometers per second through the "thick" of Halley's Comet, Giotto is not expected to survive the encounter. Because of this, it will transmit its data to Earth immediately, in "real time."


European Space Agency

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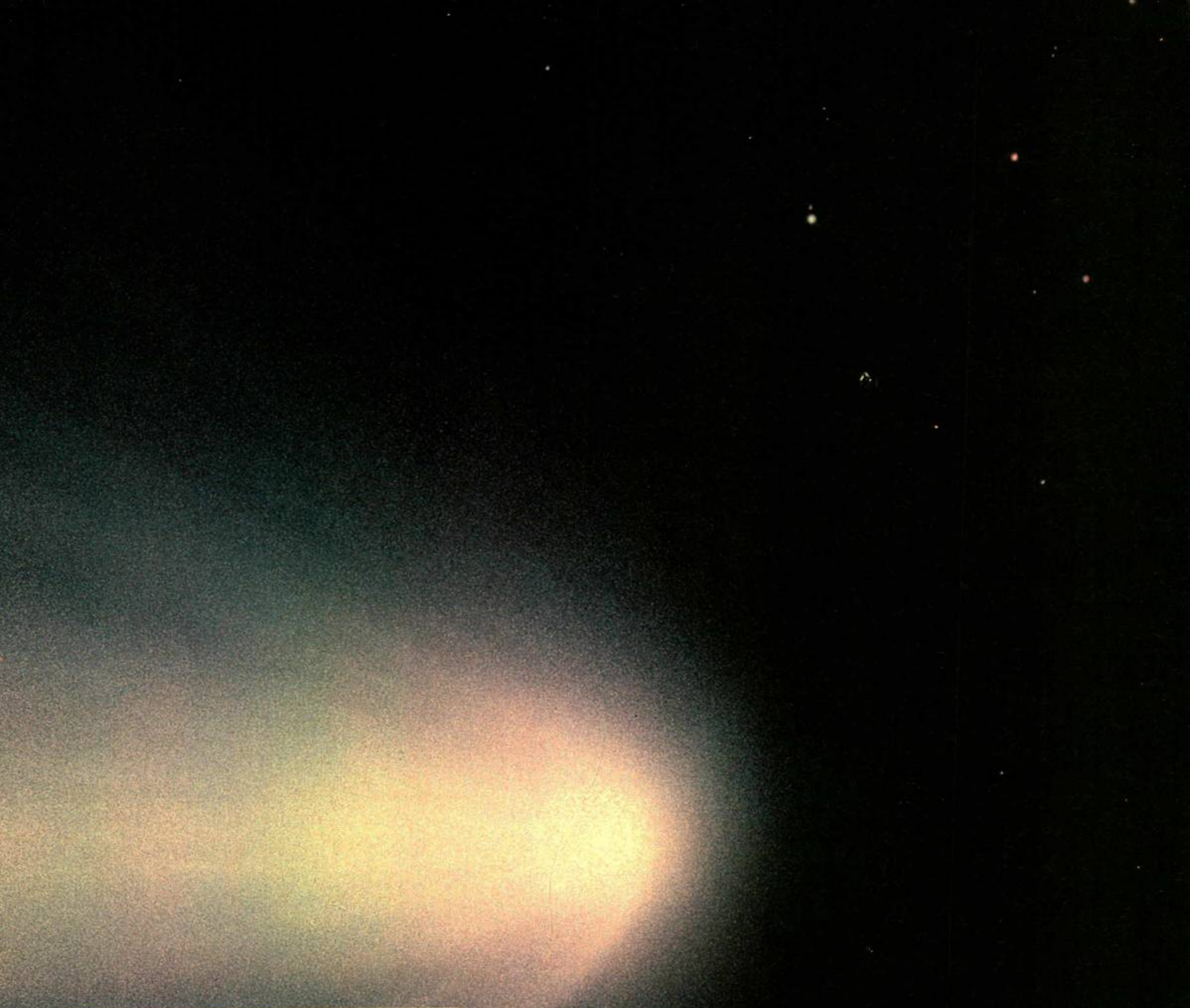
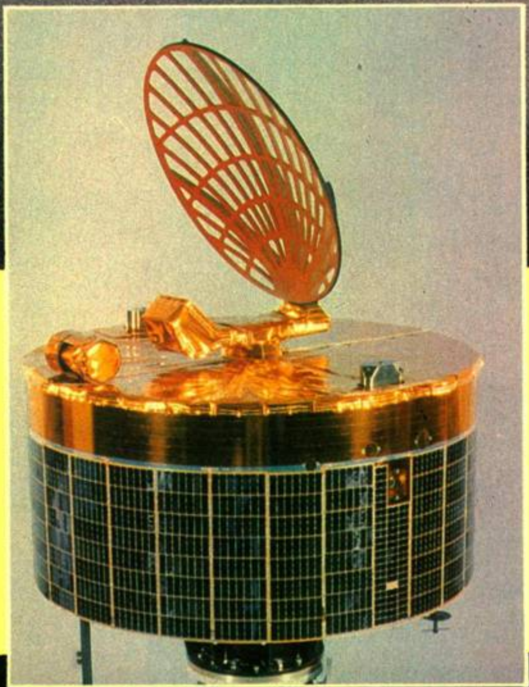


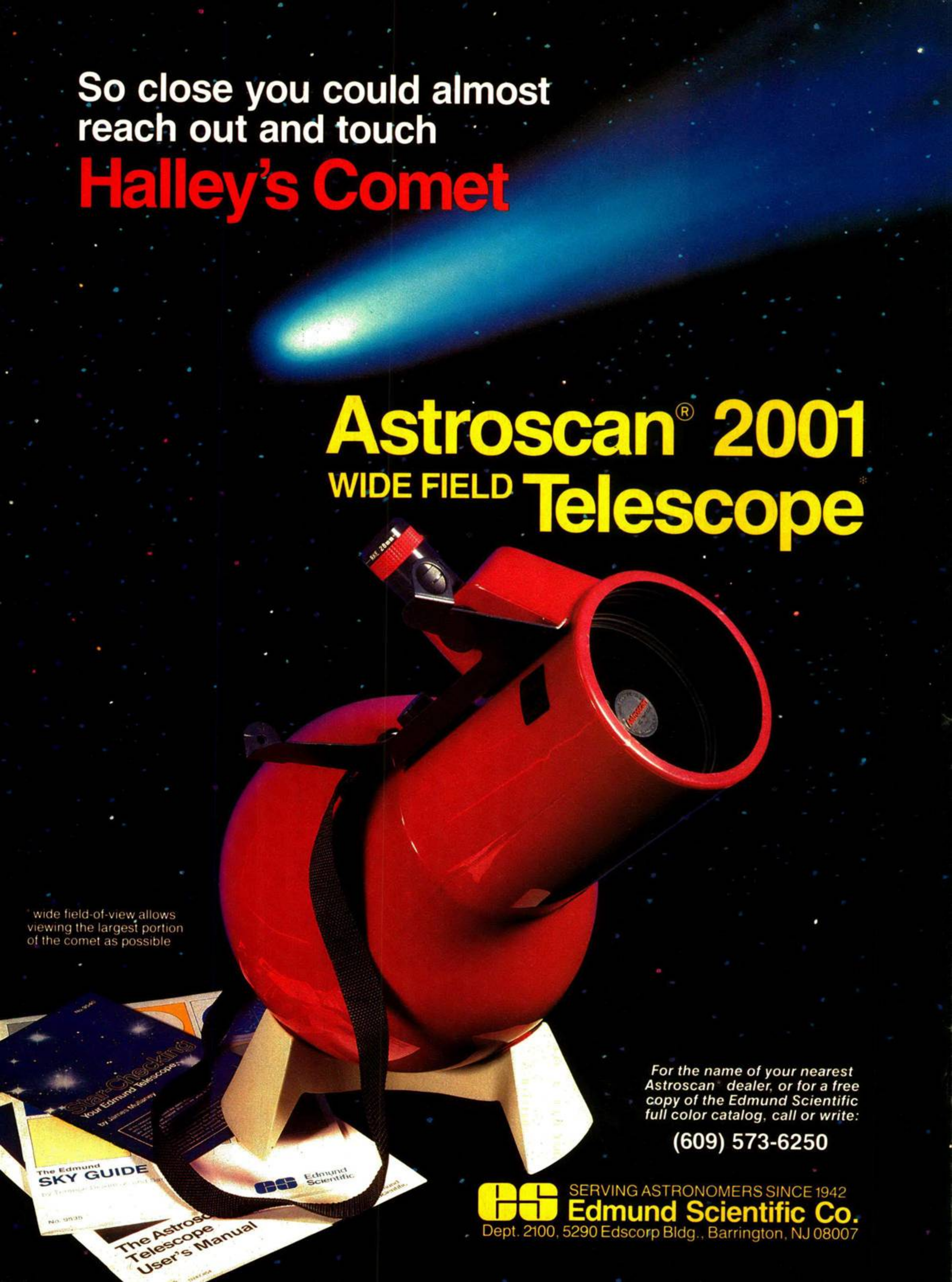


K. Hirao

Planet-A

Japan's most advanced cometary spacecraft is Planet-A; at closest approach on March 8, 1986, it will study Halley from a distance of about 200,000 kilometers. Another Japanese probe, Sakigake, was launched on January 8, 1985 and will encounter the comet on March 11, 1986. It will monitor Comet Halley's activity from some 7,000,000 kilometers. Planet-A will primarily observe how Halley's coma grows and behaves, and how the solar wind affects the comet. It carries an ultraviolet telescope and camera, and a solar wind analyzer.

Mark Paternostro Art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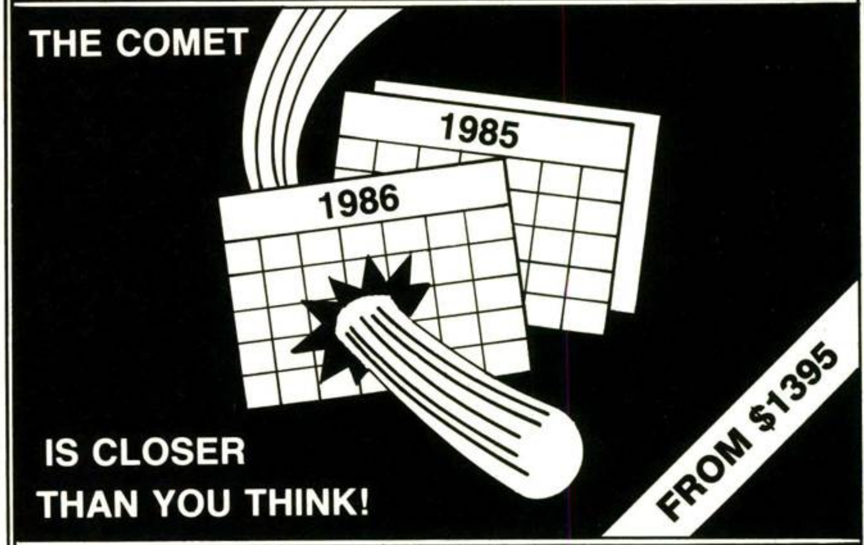

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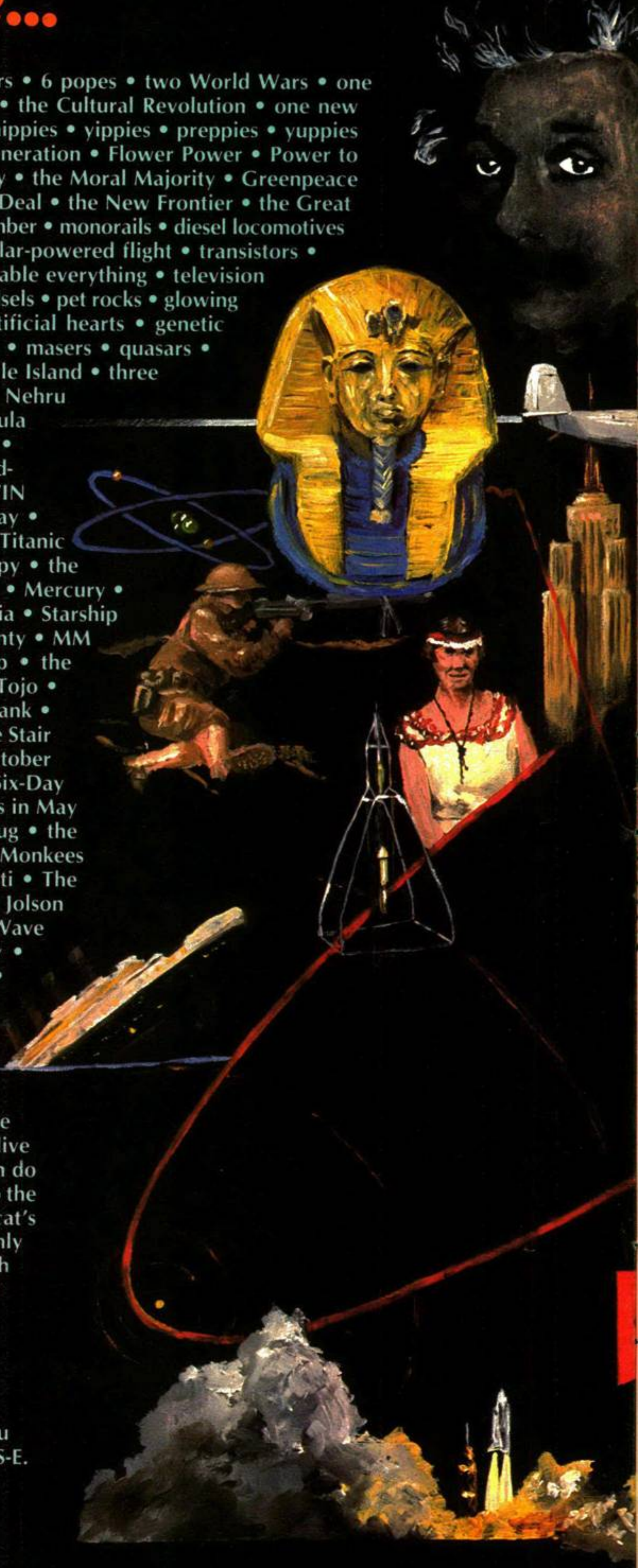

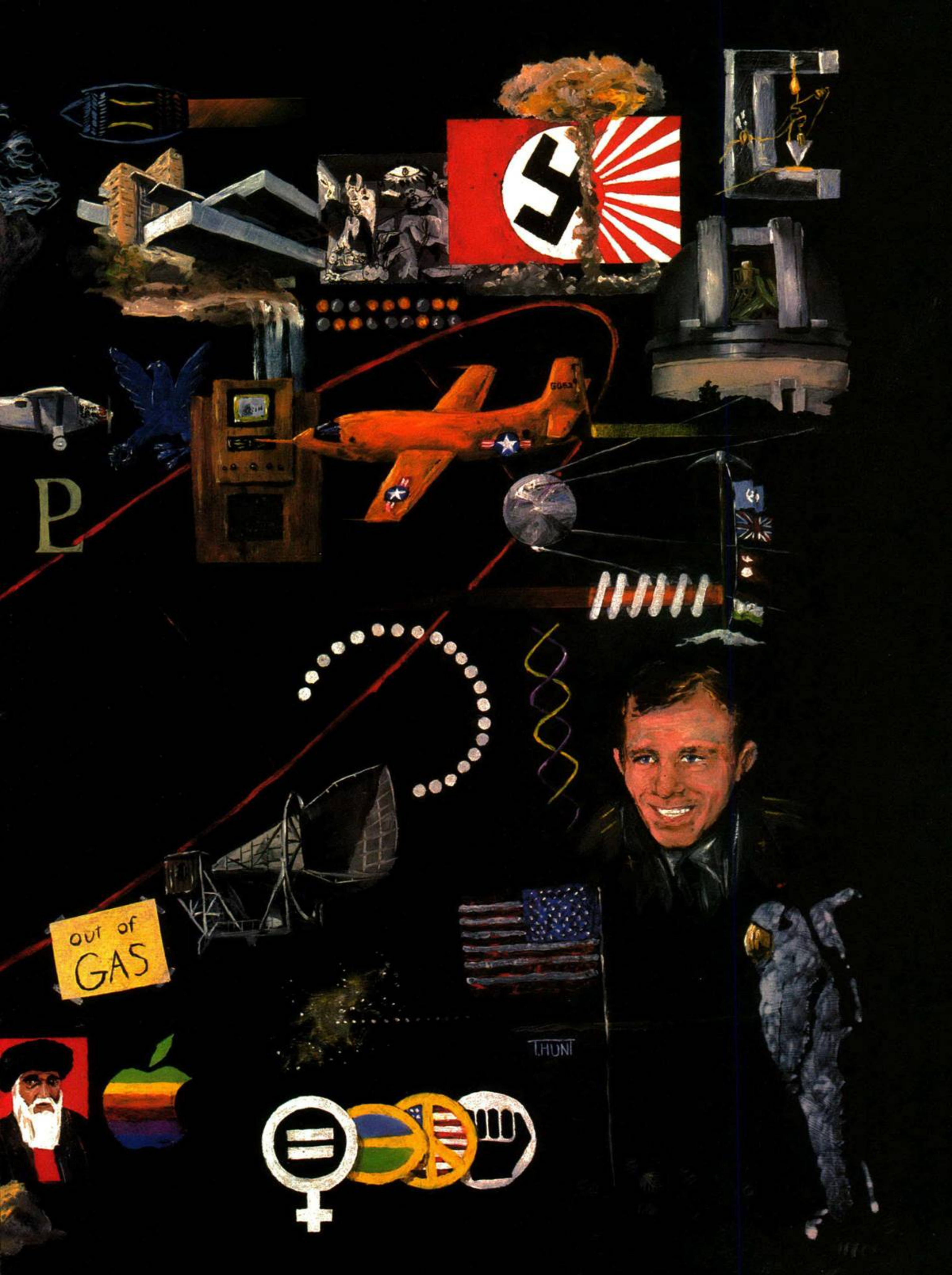
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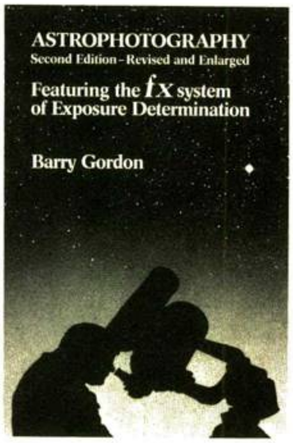

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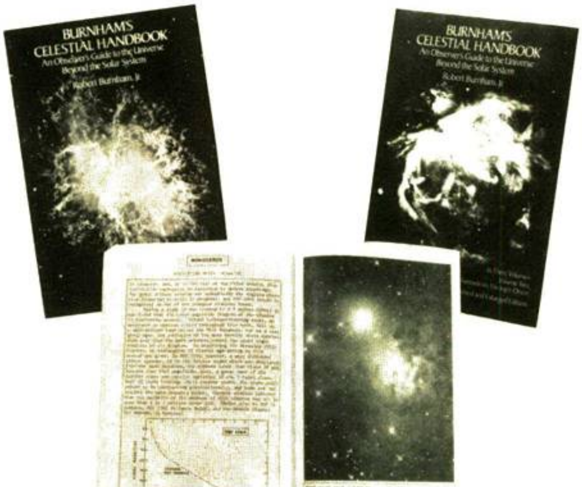
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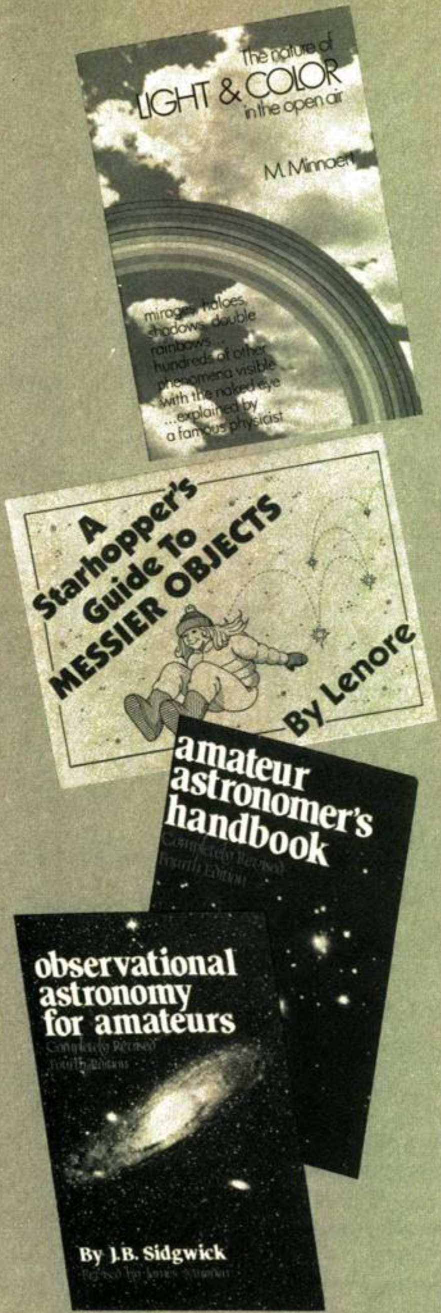
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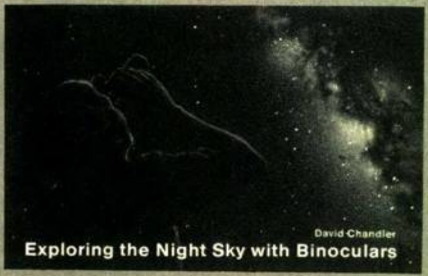
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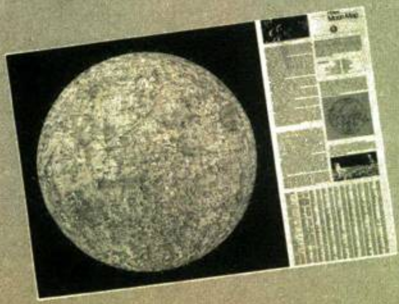

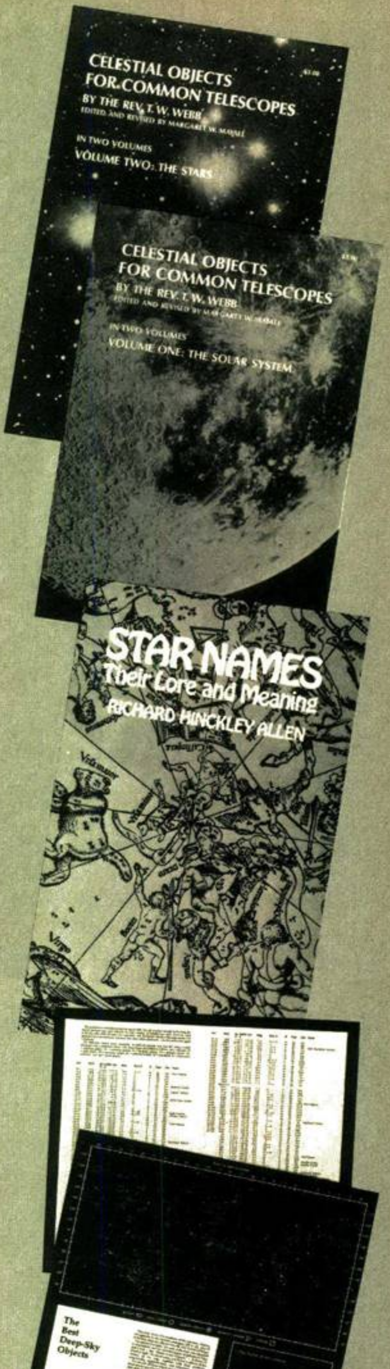
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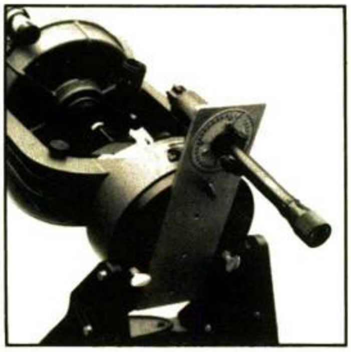

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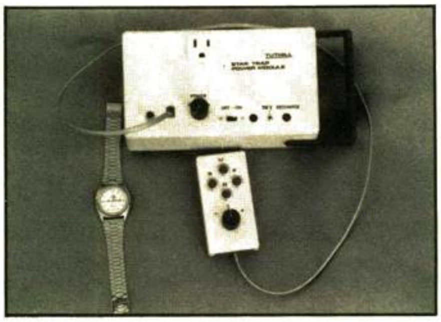

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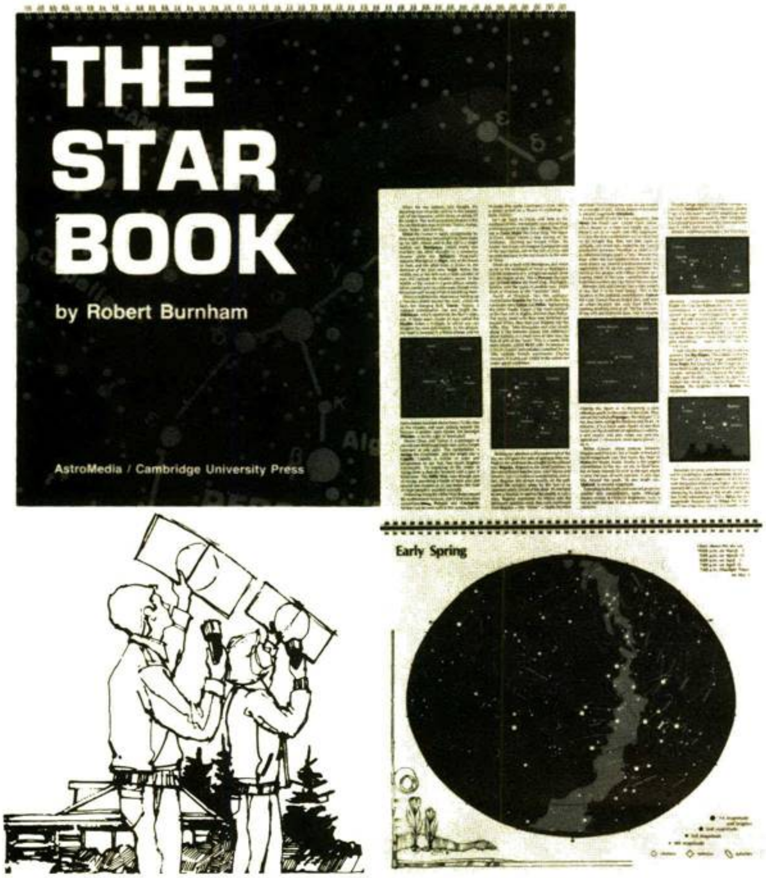

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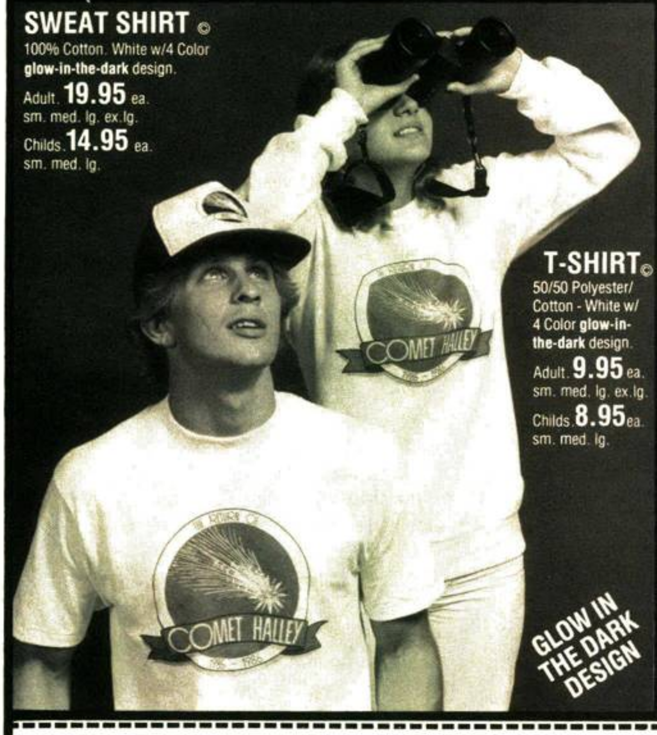

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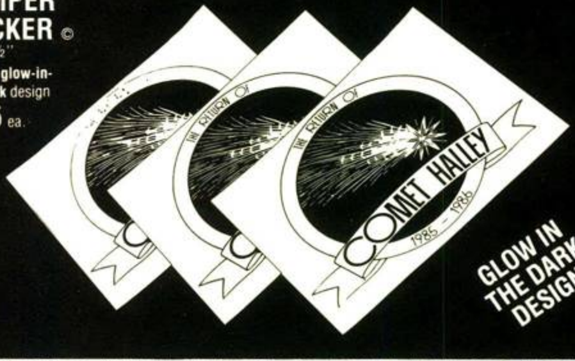

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ASTRONOMY
In Focus

"Hare" Raising?

Sir / Concerning your Skylore discussion (February 1985) about the relationship of hares to the Moon, there is in fact the figure of a long-eared animal visible on the Moon that probably represents the hares in some myths. It consists of Maria Fecunditatis and Nectaris (ears), Tranquillitatis (forehead), Serenitatis (snout), Imbrium-Nubium (chest and back), and Oceanus Procellarum-Mare Humorum (haunches). The head is complete by lunar age six or seven days, depending on the libration. The whole figure is best seen in the mid-afternoon to early evening in northern latitudes during waxing gibbous phases when the Moon is in the eastern or northeastern sky.

Some living "primitive" peoples see a different animal in the Moon. In the cosmogenic myth of the Dogon of Mali, the figure represents the primordial ancestor of the local sand fox, whose random nocturnal walks across a divination table drawn on the ground are still used to resolve social disputes. The ancestral fox, previously a misbehaving genie called Ogo, is represented by the waxing crescent Moon. Ogo originally possessed creative and other magical powers but had abused them, e.g., inventing theft by stealing celestial "seeds" (occultations of stars) and committing incest with his "mother," the Earth (total lunar eclipses). As a result, the Sky God transformed Ogo into a fox, who was granted only the power to judge human affairs with his paws. Viewed upright, the fox's head forms a Y resembling Taurus, which in the story is Ogo's birthplace. The head is also seen as the primordial acacia tree; its thorns became Ogo's claws, enabling him to divide the Zodiac into 12 parts and "plot" the Moon's ever changing paths through it. Viewed inverted, the head becomes a manlike figure with a grossly oversized head, representing the degenerate Yeban offspring of Ogo's incest. (This is the natural orientation when the Moon is west of the observer's prime meridian.)

Astronomical metaphors or allegories like those above occur in most hare-and-Moon stories, but it would be premature to propose interpretations for the abbreviated versions in your article. In any case, the stories have little if anything to do with the Greek constellation Lepus.

Philip C. Steffey
Santa Monica, CA

Hot Glass!

Sir / In order to construct a low-power wide-angle RFT for viewing Halley's Comet next year, I bought a huge army-surplus 6-element 38mm Erfle eyepiece (used in tank periscopes and telescopes in the 40's and 50's) at the swap meet during this year's Riverside Telescope Maker's Conference. Over the years, this and similar eyepieces have appeared in many magazine ads and surplus catalogues at prices ranging from \$12 to \$120. I was told the glass was a rare-earth high-refractive-index type, which accounted for its yellowish color.

After returning home with the lens, I checked further with a knowledgeable optician. He said the yellow glass in this design serves only as a filter which removes blue light to give a better visual image. He also noted that older glasses were often colored yellow with uranium compounds, so I checked the lens with a radiation meter. The result: a total alpha, beta, and gamma radiation emission level of almost two milliroentgens per hour (0.002 R/hr).

Although this is a small number, someone using this eyepiece would receive roughly 1200 mR or about 24% of the Nuclear Regulatory Commission's recommended maximum yearly *whole-body* dose (5 REM) — a small number, but no longer biologically insignificant because the dosage is delivered to the eye, a radiation-sensitive (in more ways than one) organ.

For energetic beta particles and gamma radiation, there is a nearly one-to-one correspondence between the roentgen and the Roentgen Equivalent, Man (REM). However, a roentgen of the highly-ionizing alpha particles can equal much more than one REM.

This level of radiation intensity, especially from the highly-ionizing alpha particles (absorbed mainly by the cornea) and from the more penetrating beta particles (absorbed by the lens and other internal structures) could have serious consequences over the years. The probability of my developing external or internal cataracts, or of sustaining other eye damage, could well be increased.

Since my unimpaired vision is a precious asset, particularly for continuing the pursuit of observational astronomy, I have decided to shelve this lens after labeling it with a radiation warning. I strongly recommend that all amateur astronomers check their old government surplus optics for conformity to the NRC's most recently issued permissible radiation levels for eyepiece lens surfaces.

Stephen D. Greenberg
Livermore, CA

Florida "Halley Rally"

Sir / With Halley's Comet just around the corner, amateur interest is really beginning to soar. I recently contacted the Everglades National Park in Florida with the thought of holding a national "Halley Rally" there next year and received a favorable response.

The area chosen for the rally is Flamingo, which borders Florida Bay and should afford an excellent view of the south and east. Maps of the Everglades are available from the park at P.O. Box 279, Homestead, FL 30030.

Accommodations within the park are

limited (overflow camping outside the developed sites is not allowed), although there are numerous campgrounds surrounding the Everglades. Homestead is about 48 miles from Flamingo and Miami International Airport is 83. Room and/or campground arrangements are strictly the responsibility of the individual. This is not a planned tour but rather a convenient site for amateurs to gather and observe together, so no daytime activities will be planned. The park entrance fee is $2.00 per car, which is good for 14 days.

The "Halley Rally" is not restricted to a specific day or weekend. It seems the first two weeks of April, 1986, will be the best, however. This is all I have to date, but will be happy to mail updated information to interested individuals who send me a self-addressed, stamped envelope.

Phil Harrington
54A Dillmont Drive
Smithtown, NY 11787

Fie on Armchair Observing!

Sir / I can't believe no one's responded to "The Armchair Observer" by Richard Bienkowski (April 1985 issue). I thought, "Boy, those amateurs out there are really going to let him have it!" But no one has, so it might as well be me.

All right. What if Galileo had been an armchair observer and just sat in his favorite chair reading the works of Aristotle? Or what if Newton had been satisfied that Copernicus sufficiently described the universe? What if Einstein had been totally comfortable with Newton's description of gravity? I could go on, but you get the idea.

The field of astronomy is growing every minute — we cannot just sit back and look at pictures from last month or last year. Yes, such activity is fine for cloudy nights, but what kind of a library would Mr. Bienkowski have if everyone had his attitude? Astronomy is for tough, dedicated people and if a person can't take the cold, the bugs, and operating the equipment, he ought to get out of the observatory — which, I guess, Mr. Bienkowski has.

Amateur astronomers can make valuable contributions to the field of astronomy and with Comet Halley coming, we need all the help we can get. The last thing we need is a load of "sit back, relax, and let somebody else do it for us" propaganda.

If Mr. Bienkowski isn't going to put his plastic-wrapped Cassegrain to work, he ought to donate it to some school where it might serve somebody. A telescope is a terrible thing to waste!

Jonathan E. Dolby
Williamsburg, PA

Behind the Scenes

Discovering the Stars

The copy of ASTRONOMY you now hold in your hands is an extraordinary issue, for not only is it the largest issue ever, but it will enjoy the broadest distribution and the largest readership we have ever reached. When six months ago we began planning it, we thought long and hard about what we should put in it. We could have approached the top astronomers in the world and asked them to write about the latest comet theories, with diagrams showing dust and gas production rates and . . . all that stuff. Instead, we asked: "What do people really want?" Overwhelmingly, the answer was, "We want to see Halley's Comet."

So this issue of ASTRONOMY started out to be about seeing Halley's Comet. But it soon became more than that. As we worked on the feature and other articles, we realized that we couldn't write about seeing a comet without also writing about seeing the stars, and about discovering all of astronomy. Our feature article, "Don't Miss Halley's Comet," probably most strongly reflects that realization.

It happened again when we considered writing about comet telescopes, which in the end proved impossible. As a person with a life-long interest in the stars, I found I couldn't honestly tell you, "Go buy a telescope for Comet Halley." That wouldn't be right. Instead, my advice is, "Buy a telescope if you have an interest in astronomy. But it's not worth it for the comet alone." I'm sure that if you think about it, you'll find astronomy hard to resist.

To help you get the "big picture," we devoted Gazer's Gazette and Photography in Astronomy, two of our regular hobby departments, to what you can see and do in amateur astronomy, and how to get started seeing and photographing the heavens. Our third regular hobby department, Equipment Atlas, is the introduction to telescopes I mentioned above.

Naturally, we didn't neglect the comet entirely; we looked into its past. "Mining Old Silver" looks back 76 years, and reports on remarkable new discoveries about Comet Halley which have come from photos that lay neglected for over half a century. Our Stellar Frontiers, "A Halley Chronicle," examines the historical record of Halley's Comet's encounters over the last two millennia. That vast stretch of human history pales, though, against the panorama of astronomical time scales.

Still, there's a human side to astronomy. In our Forum department, you will see how astronomy affects the lives of five individuals who have discovered their own stars. Beginning with a plea by George Ellis and Don Garland to amateur astronomers not to retreat from the comet-caused limelight, we then turn back to an earlier age and Camille Flammarion's self-promotional predictions of comet-wrought death and destruction. Fred Schaaf reports on the successes and failures of Dark Skies for Comet Halley, an organization attempting to get city councils and politicians to shut off the lights next winter so that every citizen can see the comet — and the stars. We next read of James South's obsessive and tragic quest for a perfect telescope, but end on a light note with Beverly Mosier's delightful piece, "Hot Tub Astronomy." As you will see, astronomy means very different things to different people.

Preparing the articles and charts for this issue turned out to be a lot of fun. In writing about finding the comet and choosing a telescope, we passed successive drafts of the manuscript around the office — so that everyone contributed. Some of the very best ideas came from non-astronomers asking "stupid" questions about those "very obvious" things that aren't obvious at all, and which newcomers to astronomy most need to know.

Of course, if you're one of ASTRONOMY's dyed-in-the-wool readers, you may not need our comet finder charts — but we'll bet you know someone who does! Please let them know about us. And if you're new to astronomy yourself and seeing ASTRONOMY for the first time, we hope you'll find that our charts and articles are just what you need to discover what a wonderful thrill astronomy gives — and keep coming back for more.

Sincerely,

Richard Berry

Richard Berry
Editor-in-Chief

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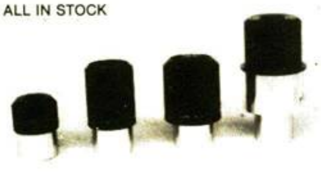

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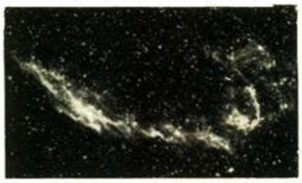

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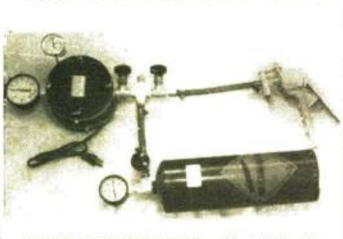

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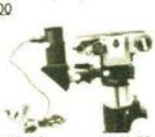

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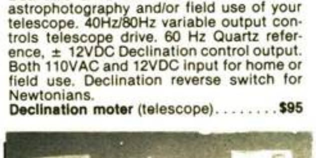

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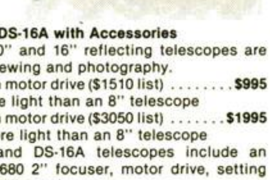

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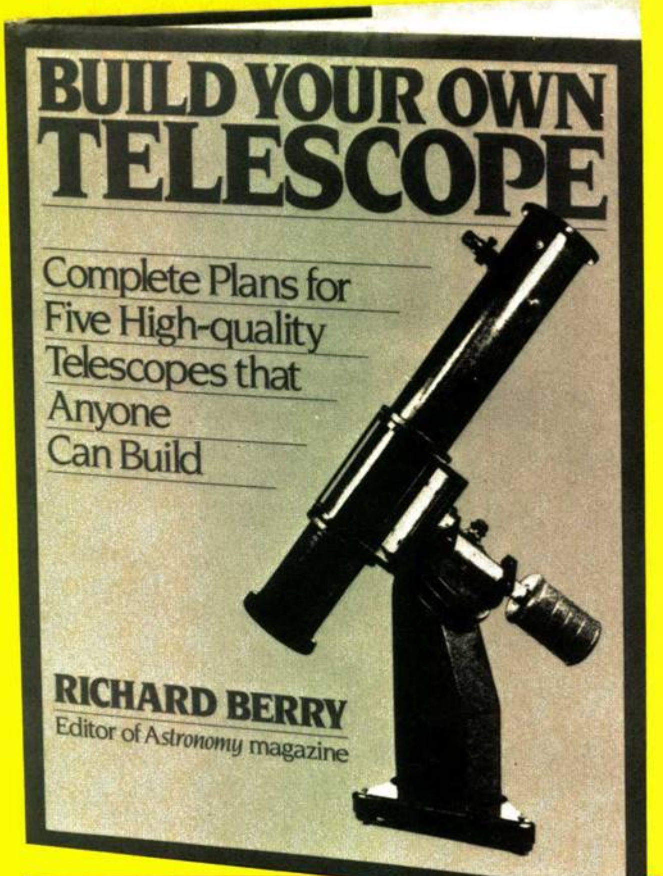
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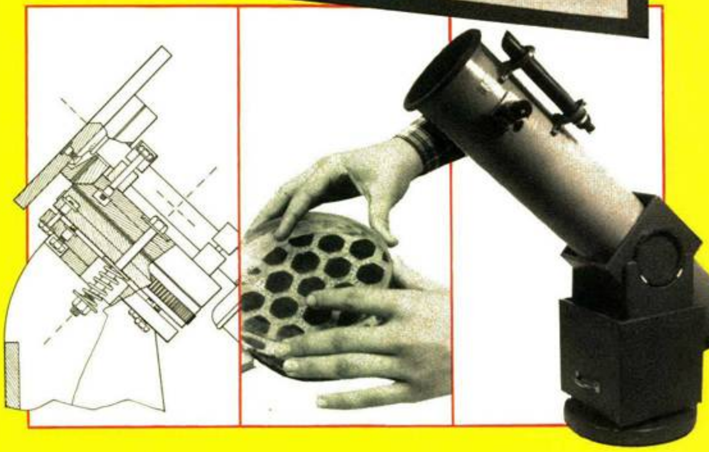

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Photography
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Celestial Photography is Easier Than You Think

ASTROPHOTOGRAPHY! The very word conveys a sense of the mysterious and the technical. Together the words "astro" and "photography" suggest that making portraits of the sky is difficult, or requires technical background and a mass of practical know-how. But that simply isn't true. In reality, it's almost the opposite: beautiful photographs of the sky and celestial objects can be produced with virtually no practice using just a 35mm camera and lens, good fast film, a sturdy tripod, and a cable release.

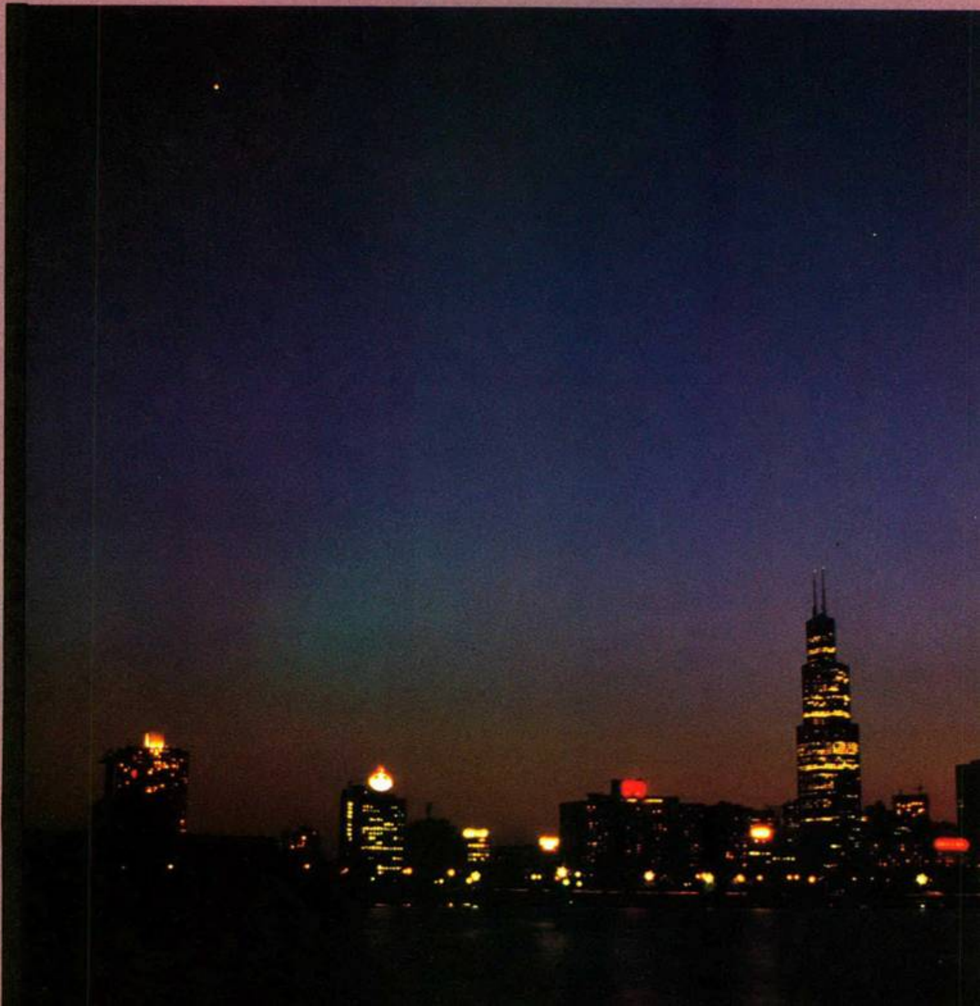
So suppose there's an attractive grouping of Venus, Mars, and the Moon tomorrow morning, or you want to record Halley's Comet rising over cornfields in the east. Just how do you go about getting your feet wet in the field of astrophotography? First, let's talk about the equipment.

Foremost, you'll need a reliable camera that you're comfortable using. The camera must meet one stringent requirement: it must be capable of long time exposures. If your camera has a "B" or "T" setting, you'll probably be able to lock the shutter open using a cable release for virtually as long as you want. Beware, however, since certain "automatic" cameras whose metering systems run on batteries may drain their energy during just one exposure. In this case, a half-hour star trail photo could entirely deplete the camera's batteries. So read the camera's instruction manual thoroughly. If you can't deduce the battery situation from the manual, contact a camera dealer and explain your desire to make long time exposures.

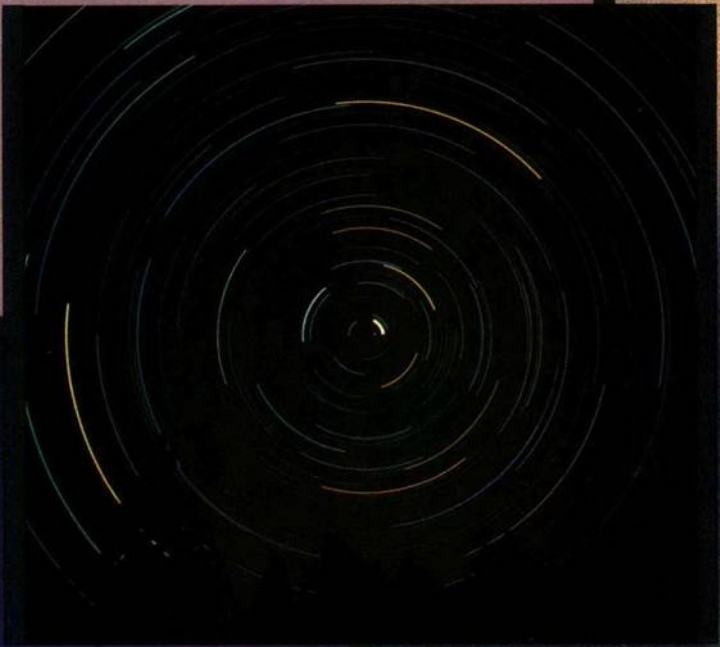
The camera's lens will significantly affect how your photos turn out. It has two important properties you should learn about: focal length and focal ratio. The focal length of a lens determines how much sky the camera's field of view will cover — the shorter the focal length, the wider the view. A standard 50mm lens spans only 40° x 27°, but a 28mm lens covers a huge amount of sky — some 65° x 46°! The focal ratio of a lens determines its photographic speed: the smaller the ratio, the faster the lens at recording incoming light. Ideally you'll want to operate at f/1.4 to f/2.8, but f/3.5 is also acceptable.

Once you've figured out the inner workings of your camera, purchase a cable release — a cable which locks the shutter open for time exposures so you don't have to jiggle the camera or hold the shutter button for half an hour. You don't have to have a tripod — you could brace the camera between two rocks or place it on a car hood — but it sure is handy. Be certain you get as sturdy a tripod as possible. Many inexpensive ones are fairly flimsy.

You'll also need some fast film. The "faster" the film, the higher the ISO (ASA) number and the more quickly it records a given amount of light. Camera-and-tripod astrophotography requires fast film for a couple of reasons. Earth is continually rotating about its axis, causing stars to appear to move across the sky. By keeping exposures short, you can avoid having trailed stars in your pictures — and in order to record much of anything in a 15 or 30-second exposure, you need fast



Right: A 50mm f/1.8 lens, 400 ISO film, and a 30-second exposure combined to make this photograph of a brilliant aurora over Edmonton, Alberta. Photo by Brian Tkachyk. Below: A camera lens pointed toward the north celestial pole and left open — this one for 3 hours 45 minutes — will record stars trailing around the pole. Photo by John Kerns. Below left: Cityscapes provide attractive foregrounds — here Venus hovers over Chicago. Photo by Peter DiJulio.



Far left: In 40 seconds' time, a 50mm lens set at f/2 and 100 ISO film recorded Comet West over Holy Hill, Wisconsin in 1976. Photo by W. Edwards Brown. Left: Two years earlier, the same setup captured Comet Kohoutek, Venus, and Jupiter. Photo by W. Edwards Brown.

Below left: In March 1970, Comet Bennett dominated the evening sky and could be photographed in a 1-minute exposure with a 50mm lens. Photo by W. Edwards Brown. Left: From his backyard, Mark Erickson photographed Comet West using a 50mm lens and 1-minute exposure. Below: Dale Slechta photographed Comet West using a 50mm lens.

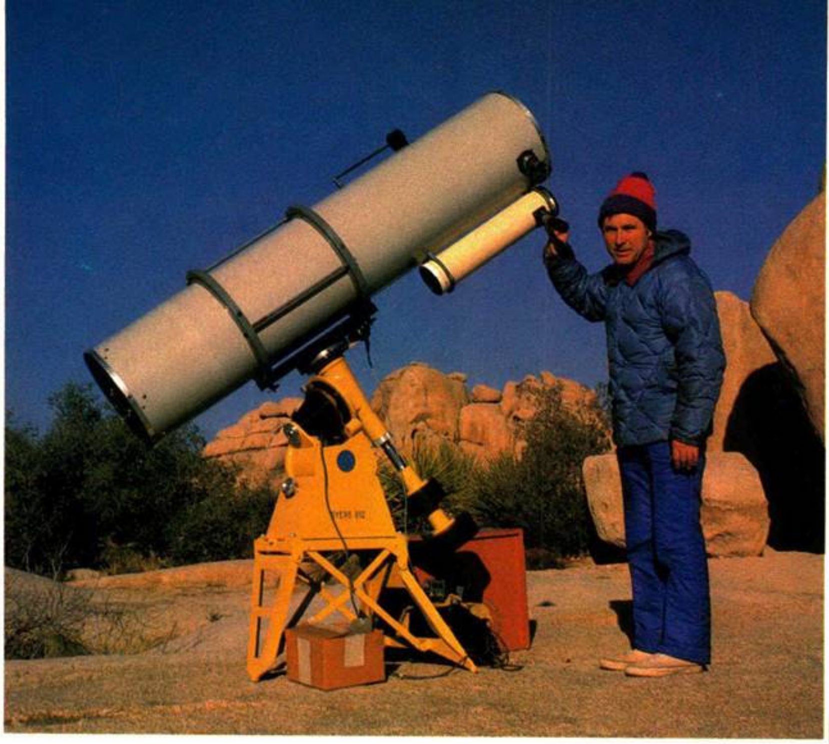
film. ISO 400 speed slide films are pretty good, but you might also want to try one of the ISO 1000 films. All 1000 speed films are grainy, but will record stars in short exposures. The 400 speed stuff is slower, but its resolution is better. Try several types of film to see what suits your taste.

The obvious center of attention for simple astrophotography this winter and next spring is Halley's Comet. To ensure that you come away with nice pictures of this once-in-a-lifetime sight, get outside and practice taking astrophotos *now*. First choose a subject — say, the constellation Andromeda — and use ASTRONOMY's Star Dome (see pages 72 and 73 of this issue) to locate it in the sky. While inside, load your camera with film, then take the camera, the tripod, the cable release, a flashlight for setting up, and a current copy of ASTRONOMY's star map outside. With short exposures, you don't need a terrifically dark site — but it helps. Set the tripod on a patch of flat ground and attach your camera on top. Now fit the cable release onto the shutter button, focus the camera at infinity, open the diaphragm to the lowest f/number, compose the shot by spotting Andromeda through the viewfinder, set the camera on "B" or "T," and start the exposure.

In astrophotography, experimentation is the best way to learn. Try a 2-second, 4-second, 8-second, 16-second, etc. series of exposures to see which comes out best. You'll probably find that star pictures somewhere in the 16 to 32-second range give untrailed images and show the brightest stars in any given constellation pretty well. But just to see what happens, take shots lasting 5 minutes, 10 minutes, 20 minutes, and even 40 minutes. Be sure to take notes on what exposures you use — that way you can decipher the results from the photofinisher. You can even walk away and leave the camera shutter open while getting some hot chocolate inside. As long as you come out and stop the exposure after the desired amount of time, you need only worry about three things: the lens fogging up with moisture (a portable hair dryer turned on low and aimed from the side, not in front, of the lens alleviates this problem), a passing vehicle's bright headlights shining into the lens, or someone coming along and stealing your camera!

After you practice taking pictures of different sky objects with different foreground settings and different types of film, you'll begin to refine the art of astrophotography and discover your likes and dislikes. Remember, the best teacher is practice — and the subject of the century, Halley's Comet, will soon be bright enough to photograph with camera and tripod. Spend a little effort now to learn about photography through hands-on experience, and you'll find documenting the sky's most famous visitor is a "snap"!

— David J. Eicher



Ronald Royer

Special Techniques = Great Results

What if you want to get a bit more sophisticated with this astrophotography thing? After all, Halley's Comet will only be around for a few months — and even then not all the time. What can you do to get the best possible photographs of the comet?

A powerful advance over tripod-and-camera photography, guiding your camera so that it exactly compensates for Earth's rotation — and tracks on the stars or on a comet — gives you greater freedom. You can expose film for longer periods, thereby recording fine detail in a comet's tail without the light smearing into an undecipherable blur. How can you track your camera at the correct rate? There are two ways. First, you can buy a commercial equatorial mount. This is a moving platform designed to be aligned with the north celestial pole — the point that stars appear to rotate around — which turns at a constant, predetermined rate in order to keep the stars looking like points. Or, in the case of photographing a comet, you can track directly on the comet's head itself. You may have slightly trailed stars, but the comet will photograph clear and sharp (see "Easy Steps to Perfect Polar Alignment," August 1982 issue). Or you can build a simple, inexpensive mechanical platform, which you can easily turn at the correct rate by hand (see "A Portable Astrophotography Platform for Travelers," September 1985 issue).

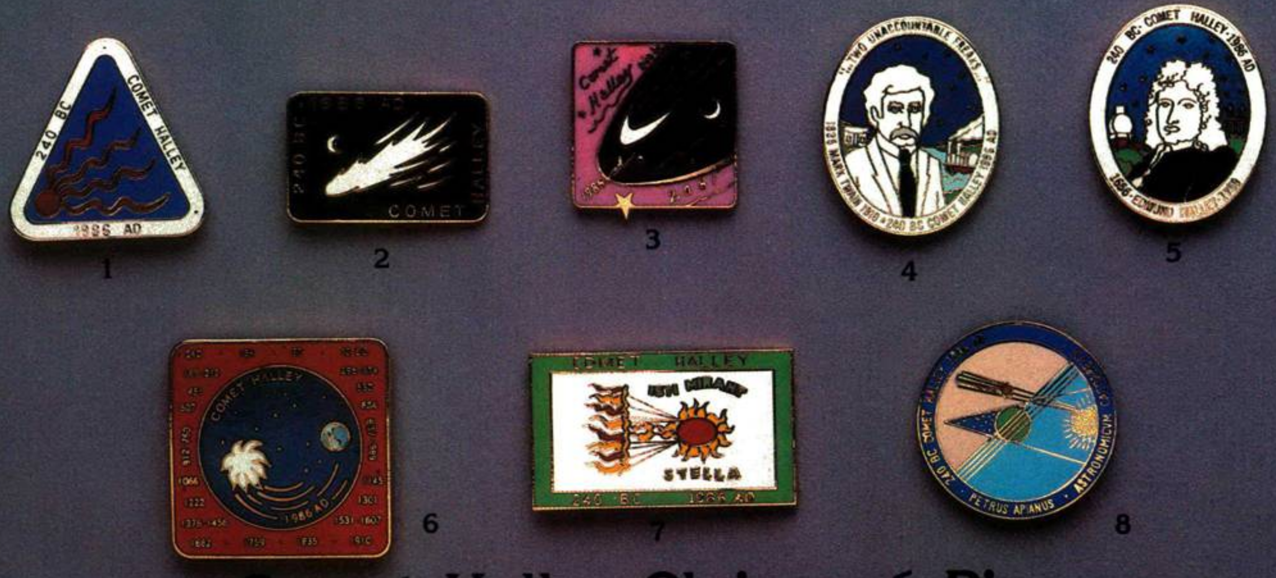
Tracking on the stars not only allows you to expose longer, but permits you to use longer focal length lenses which yield closer views containing more detail. Pick out a favorite subject — Halley's Comet, the Pleiades, the Andromeda Galaxy — and use a 150mm or 200mm lens at about f/3.5 or f/4, exposing for 15 to 30 minutes. If all goes well, you'll come away with a remarkably detailed photo showing a rich starfield and crisper images than a 50mm lens could provide.

Since the main goal no longer depends on sheer photographic speed, guided photography gives you a much wider choice of films, some of which offer markedly better resolution than the faster, grainier types. The highest resolution, best quality black-and-white film is hypersensitized Technical Pan 2415 — a rather slow, technical copying film which turns into a powerful astronomical tool when "soaked" in nitrogen and hydrogen gas (see "Hypersensitizing," parts 1 and 2, April and May 1981 issues, and "The 2415 Revolution," March 1982 issue). Two films made specifically for astrophotography, IIa-O (blue sensitive) and IIa-D (red sensitive), offer fine resolution and high speed but are difficult to obtain.

Good color films are easier to find — any of the new ISO 1000 speed films provide interesting results, although they are fairly grainy. The ISO 200 version, along with added exposure time, does a better and more pleasing job. Kodak's Ektachrome 200 has a good color balance and is fine grained enough to suit most needs.

Whatever astrophotography setup you use for Halley's Comet — and future sky-shots as well — be sure to send the results to ASTRONOMY, including complete data. But don't give up on your "losers." An otherwise terrible photograph I took of Comet Austin (1982g) through cloud cover became the central piece of evidence in a professional study because of a strange kink in the tail which showed up in the photo! Astrophotography isn't as difficult as it appears at the outset — patience and practice can easily make *you* a successful backyard astrophotographer!

— Ronald E. Royer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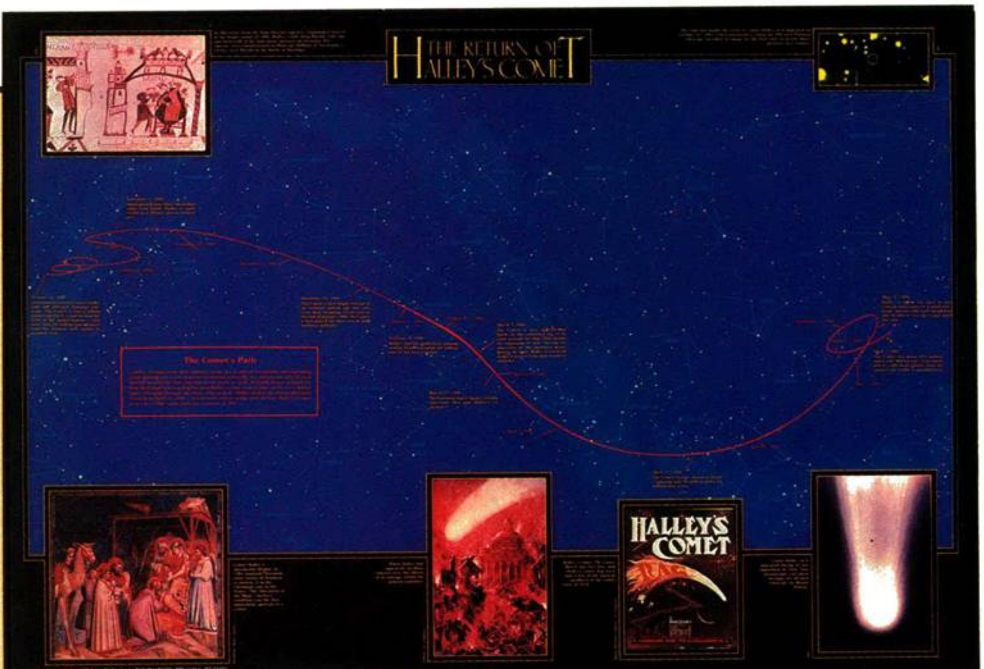
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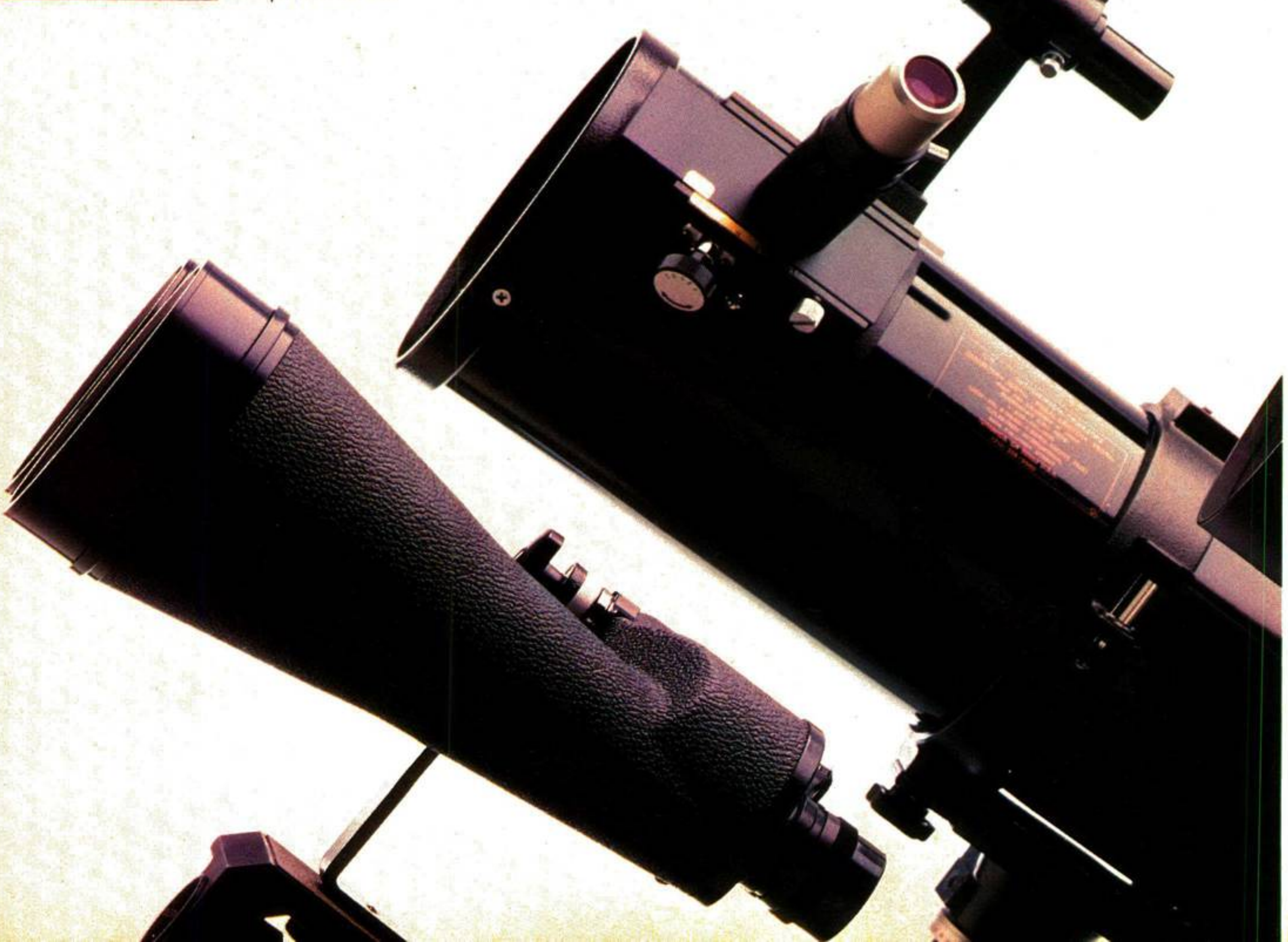

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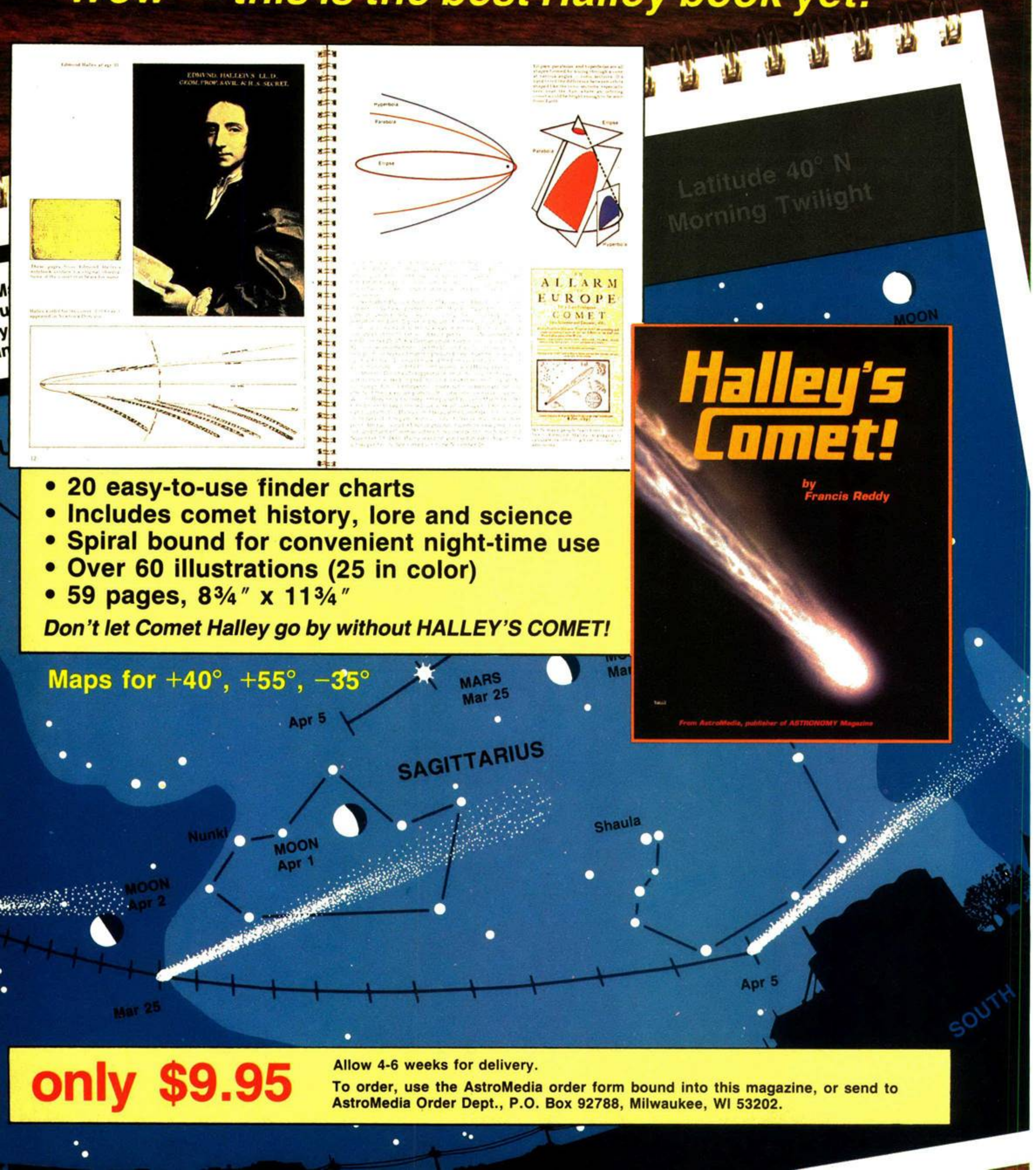
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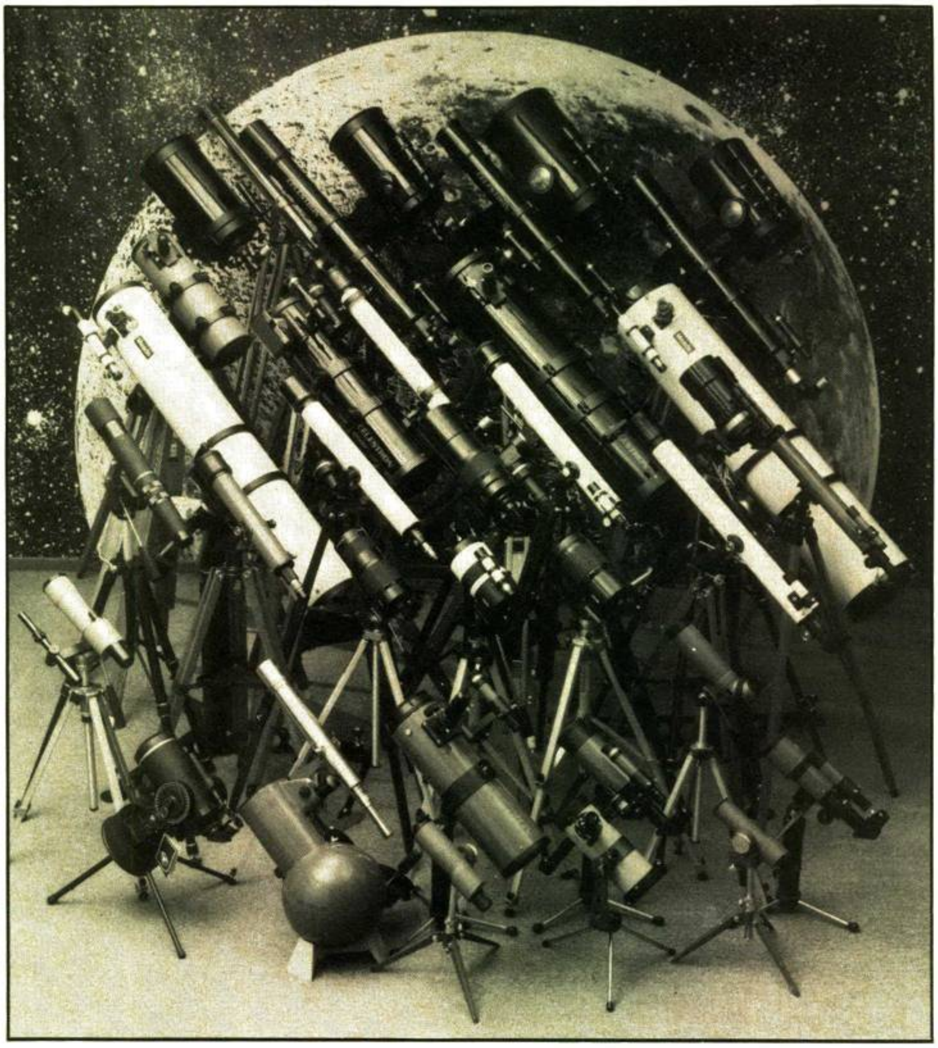

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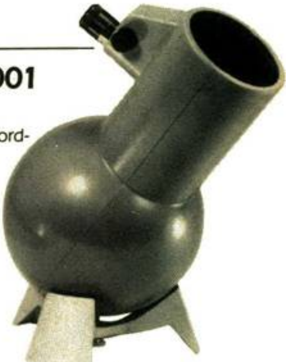

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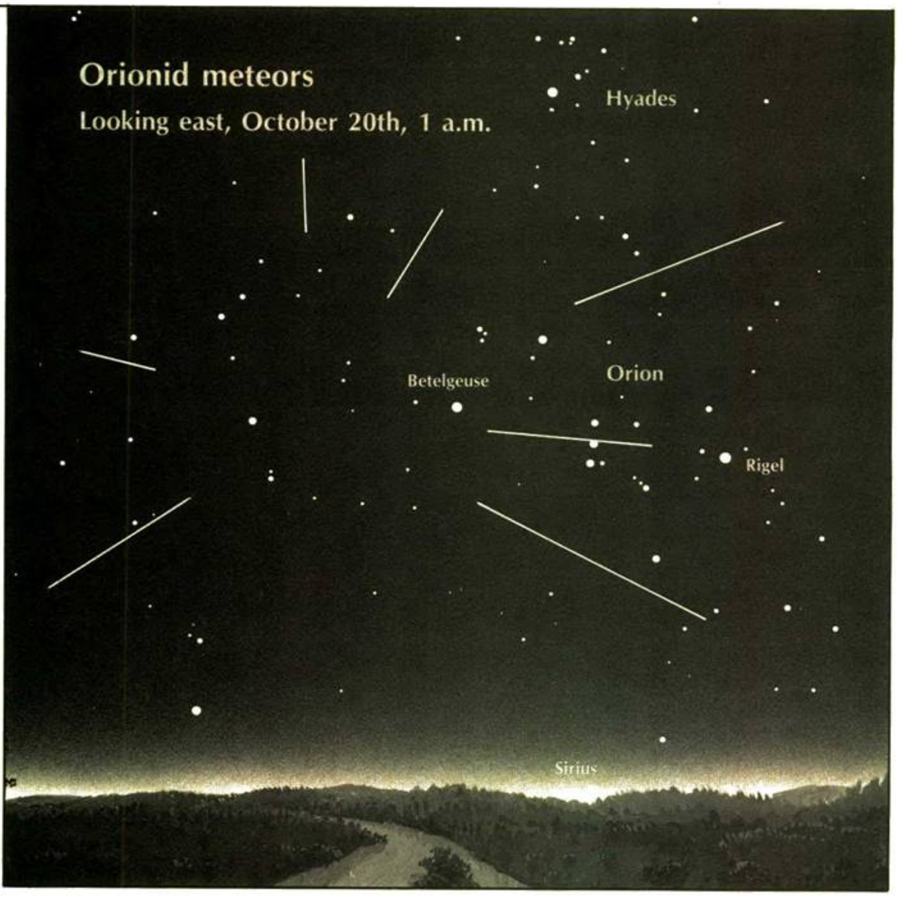
Eye on the Sky

A Month of Showers

by Fred Schaaf



Orionid meteors

Looking east, October 20th, 1 a.m.

The Wanderers

The sky-sights visible in any particular month are a combination of the long-expected and the unpredictable. Thus we know that on October 4th and 5th, Venus and Mars will form a striking pair in the eastern morning sky. But we can only speculate whether the Draconid and Orionid meteors will put on superb — even great — displays this month.

In the opening months of 1985, **Venus** and **Mars** paired up together in the sky for a length of time that won't be duplicated again in our lifetimes. There were two conjunctions in February, and on October 4th, a third and final Venus-Mars conjunction — the last until August 1987 — should be very close.

Both planets are near their faintest, but Venus is still brighter than magnitude −3 and Mars brighter than magnitude 2. Because of their high altitudes in the sunrise sky, they will be easily visible — but catch them early before they're lost in the brightening glow.

Although Venus and Mars are moving away from each other throughout the month, they will still be close as the crescent Moon slides down to pass a few degrees north of Venus on the morning of the 12th. When the Moon reaches Full on October 28th, it will glide through the Earth's central shadow, the umbra, producing a total eclipse visible in eastern Europe, Asia, Africa, Australia, and the Arctic. A partial eclipse is visible for other parts of the eastern hemisphere, but the Americas miss out on this entire event.

Comet Halley is still a telescopic object this month. Although it is now possible to glimpse the comet before you go to bed, Halley doesn't reach its highest in the sky until early morning hours. The comet is rapidly gaining speed; in the final third of October, it shoots out of the club of Orion and travels between Zeta (ζ) Tauri and M-1 (the Crab Nebula). Unfortunately, it must compete with a Full Moon on the 28th.

But take heart. Around the 20th, a naked-eye treat will come from this same area of the sky, the **Orionid meteors** — the dust shed from Halley's past visits. A new theory about the structure of Halley's meteor stream makes it unlikely that any great Orionid shower will occur this year. But even if the chances for a torrent of "shooting stars" are slim, amateur astronomers can make an important contribution to cometary science by carefully observing and recording this shower through the second half of the month.

The chance for a better display of meteors might come from another comet which peaks earlier this month. In the past, the **Draconid meteor showers** from Comet Giacobini-Zinner have occurred when we passed by the comet's orbit just a few weeks after the comet itself. This year, Giacobini-Zinner went by less than a month before, so we have a chance of encountering a dense swarm.

To avoid the nearly Last Quarter Moon, the best time to catch this display is 11 p.m. EDT on the 9th — but look for it on the 8th as well. This is a rare opportunity, so keep alert to see what actually happens.

As for planetary sights in the evening sky, only magnitude −2 **Jupiter** stays prominent all month. The planet becomes stationary on October 3rd, resuming eastward motion very slowly in Capricornus. First-magnitude **Saturn** won't be much to see as it drops from 50° elongation in late September to 20° in late October, when it sets only one hour after the Sun. Its ghostly Halloween partner is **Mercury**, which shines at −0.1 magnitude when it passes about 4° south of Saturn. But don't expect to see much since both planets' low altitudes at sunset make for poor observing. Try to catch Saturn earlier in October.

Rivaling the sparking lights of New York, Jupiter, Venus, and the Moon shine over the city in this photo taken in November 1984 by Alfred and David Krauss. (50mm lens, 1-second exposure, Ektachrome 64 film.)

The Starry Sky

Although many of autumn's constellations are dim, a pair of binoculars and a trip to a country site will go a long way toward helping you enjoy them. High in the north these evenings are a king — properly visible only in the country — and a queen — bright enough to behold in all but the very worst urban skies.

Cepheus the King has a pattern reminiscent of a small church or old-fashioned schoolhouse. Its brightest star is **Alderamin** (Alpha [α] Cephei), accompanied by **Alfirk** (Beta [β] Cephei) and **Errai** (Gamma [γ] Cephei) — the very northerly point of the Cepheus "church steeple." The constellation's most interesting stars may well be those which

October's Night Sky

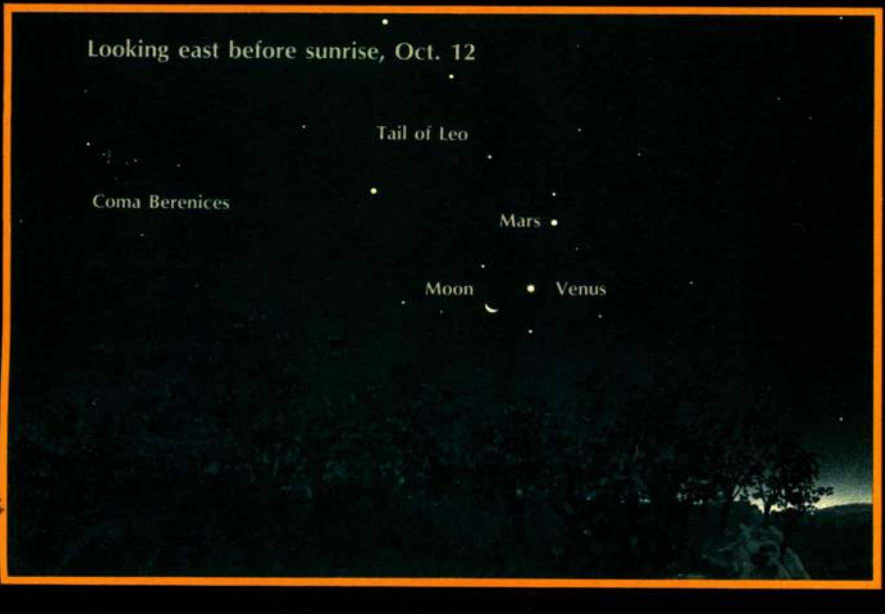
Last Quarter
October 7
1:04 a.m. EDT

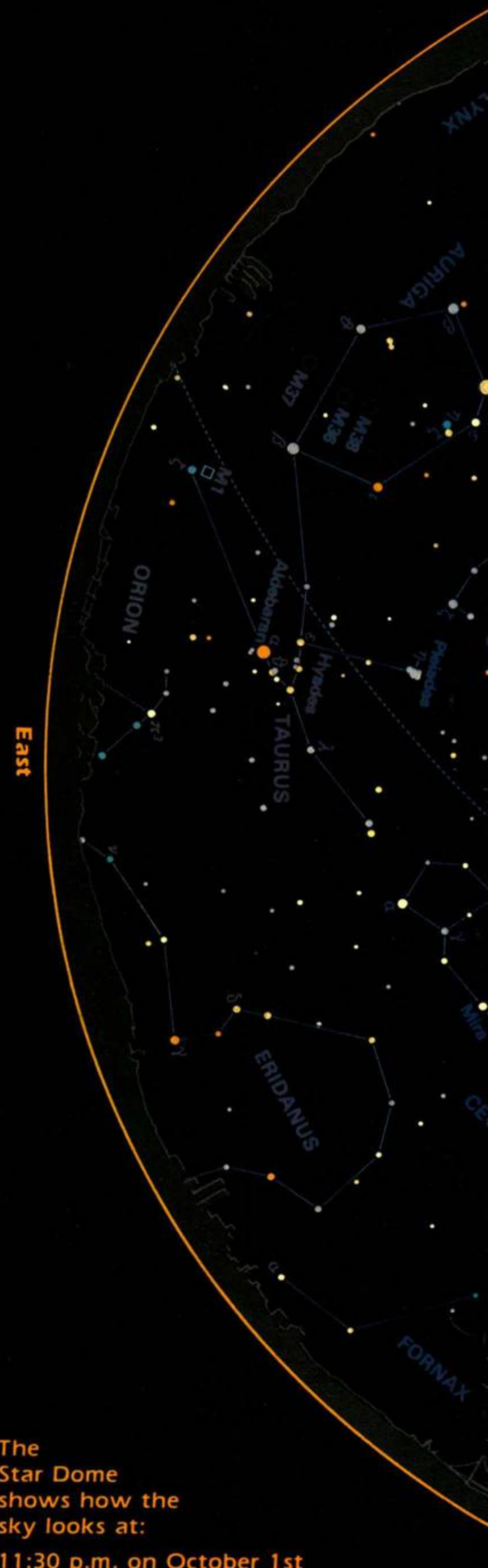
New Moon
October 14
12:33 a.m. EDT

First Quarter
October 20
4:13 p.m. EDT

Full Moon
October 28
12:38 p.m. EST

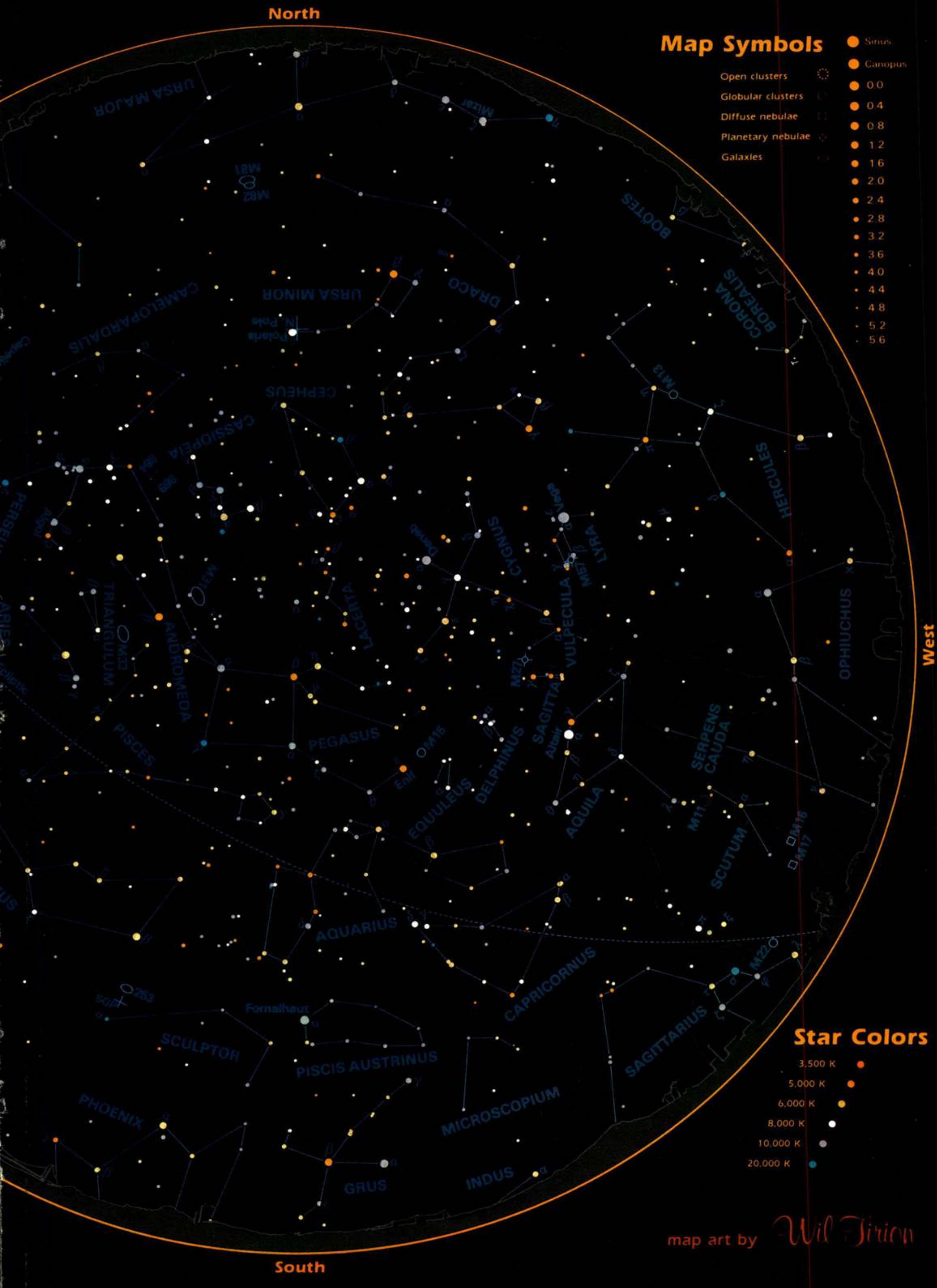
2nd	The Moon is farthest from Earth at 9:20 a.m. EDT: 252,130 miles.
3rd	Jupiter is stationary in right ascension at 6 a.m. EDT.
4th	Today and tomorrow, Venus and Mars will form a striking pair in the morning sky.
7th	Last Quarter Moon is at 1:04 a.m. EDT.
9th	The Draconid meteor shower peaks tonight. Don't miss this one — it may be a great display (see text for details).
12th	Mars, Venus, and a waning crescent Moon make a pretty grouping in the evening sky (see diagram below).
14th	The Moon is closest to Earth at 8:51 p.m. EDT: 222,626 miles; New Moon occurs at 12:33 a.m. EDT. This is a perfect time to drive out of the city to catch a glimpse of the dim fall constellations which are often lost in the Moon's glow.
20th	First Quarter Moon is at 4:13 p.m. EDT. Watch for the Orionid meteor shower over the next few nights; it may prove very active due to the nearness of its parent — Halley's Comet.
27th	Turn your clocks back one hour, as Daylight Saving Time ends.
28th	A total eclipse of the Moon — visible only in the eastern hemisphere — occurs today. Full Moon is at 12:28 p.m. EST.
29th	The Moon is farthest from Earth at 4:51 p.m. EST: 252,471 miles.


Looking east before sunrise, Oct. 12
Tail of Leo
Coma Berenices
Mars
Moon
Venus


LYNX
AURIGA
M37
M36
M38
M1
ORION
Aldebaran
Hyades
Pleiades
TAURUS
East
ERIDANUS
Mira
FORNAX

The
Star Dome
shows how the
sky looks at:

11:30 p.m. on October 1st
10:30 p.m. on October 15th
8:30 p.m. on October 31st


North
South
West
Map Symbols
Open clusters
Globular clusters
Diffuse nebulae
Planetary nebulae
Galaxies
Sirius
Canopus
0.0
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1.2
1.6
2.0
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3.2
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Star Colors
3,500 K
5,000 K
6,000 K
8,000 K
10,000 K
20,000 K
URSA MAJOR
Mizar
M81
M82
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CORONA BOREALIS
CEPHEUS
M13
CASSIOPEIA
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Deneb
CYGNUS
Vega
LYRA
M57
TRIANGULUM
M33
M31
ANDROMEDA
LACERTA
VULPECULA
M27
OPHIUCHUS
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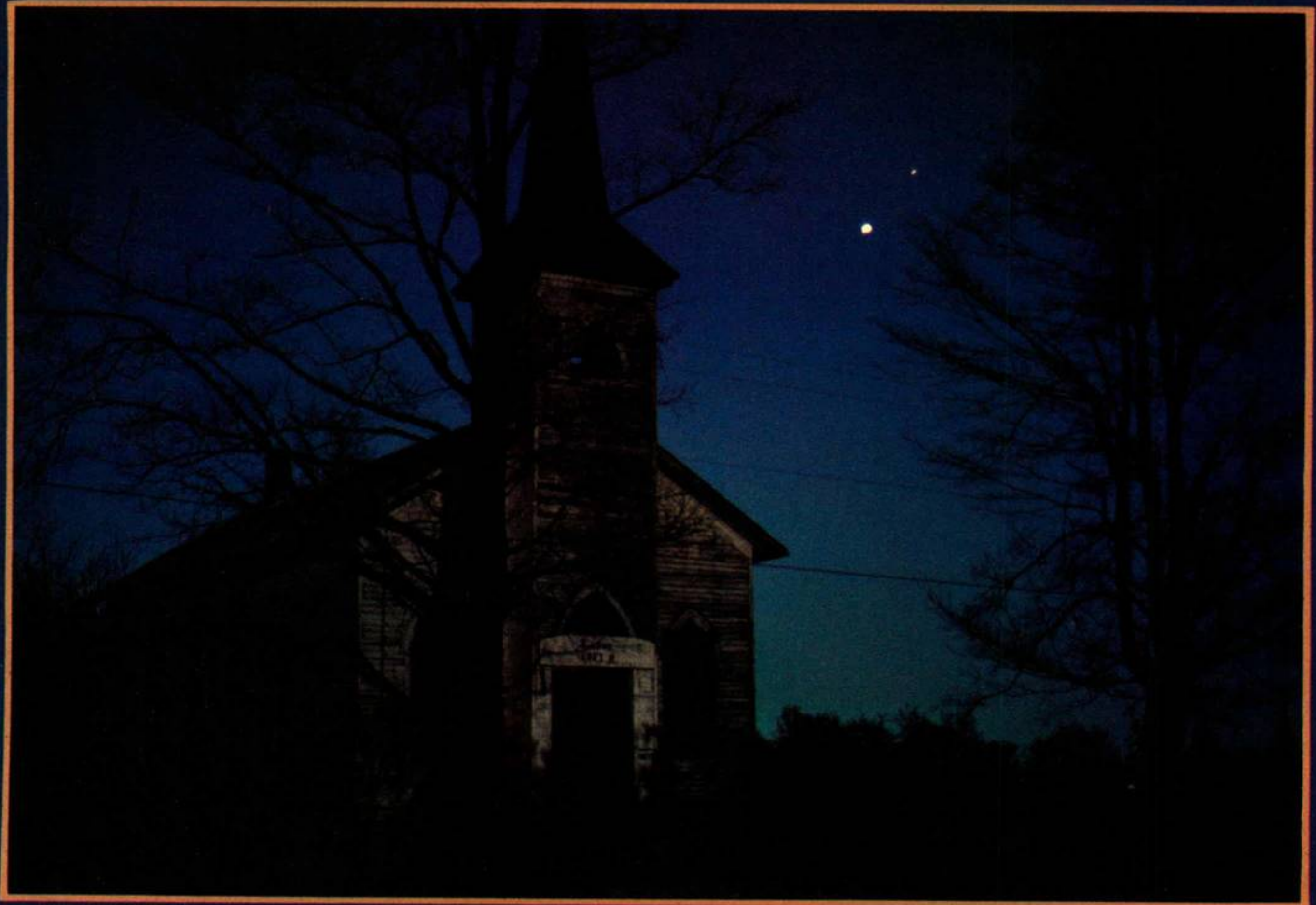
EQUULEUS
AQUILA
M11
SCUTUM
M16
M17
AQUARIUS
M22
CAPRICORNUS
SGP
253
Fomalhaut
SCULPTOR
SAGITTARIUS
PISCIS AUSTRINUS
PHOENIX
MICROSCOPIUM
GRUS
INDUS

map art by Wil Tirion



Top: The Northern Lights as seen on the morning of May 3, 1978, 20 miles north of Kettle Falls, Washington. Note the stars of Perseus and Andromeda shining in the background. Photo by Don Carney; 35-second exposure at f/1.8, 200 ASA film push-processed to 400. Bottom: This pretty Venus-Saturn pairing near a church illuminated by a gibbous Moon was photographed by Jeff Lange. He used a 50mm lens, 10-second exposure at f/1.8, and Kodachrome 64 film.

don't have proper names because their unusual natures weren't discovered until post-telescopic times.

Delta (*δ*) **Cephei** is that star from which an important class of regular variable stars, the Cepheids, derives its name. This star's changes are bright enough to study with the naked eye. How extreme are they and how long do they take? Compare it to Zeta (*ζ*) Cephei nearby.

Another star of great observational interest is **Mu** (*μ*) **Cephei**. This red giant is one of the most distant and largest stars detectable with the unaided eye, and binoculars reveal what looks like one of the reddest stars in the sky. Although it has no proper name, it does have a nickname: Herschel's Garnet Star.

Cassiopeia the Queen is Cepheus' far brighter mate to the northeast. Its zigzag pattern of second and third-magnitude stars looks more like a queen's throne than a queen — and indeed it should: lore says that Cassiopeia was so vain about her beauty that she was punished by being tied to her chair and made to whirl around the North Star, often suffering the indignity of being upside-down as she is now. A simpler way of finding this pattern is to look for the capital letter "M" high in the north on autumn evenings or "W" low in the north on spring nights.

The whole region of Cassiopeia is resplendent with Milky Way stars and star clusters — some visible as fuzzy spots of luminosity in binoculars under a dark sky. Just a bit northeast of Cassiopeia down the Milky Way stream, you can find the finest clusters — side by side — in this entire section of sky. This is the **Double Cluster** in Perseus, a pair easily detectable with the naked eye under good skies.

There is another "fuzzy," a much larger glow which is closer to its peak during mid-October evenings: the elongated strip of the **Andromeda Galaxy**, M-31. When you look at it, you are seeing a hundred billion stars over two million light-years away. Viewers around 40° north latitude can watch M-31 pass through their zenith late on October evenings, but other viewers may need some "street" directions which start with the source of all "roads" — visual lines through the stars which carry your gaze to other constellations — in the autumn sky: the Great Square of **Pegasus**, the Flying Horse.

Because of the Square's prominence, the rest of Pegasus is often forgotten — even his second-magnitude nose **Enif** (Epsilon [ε] Pegasi). The body itself is formed by a rectangle of bright stars but the upper left star, **Alpheratz** (*α*), is actually borrowed from the constellation Andromeda.

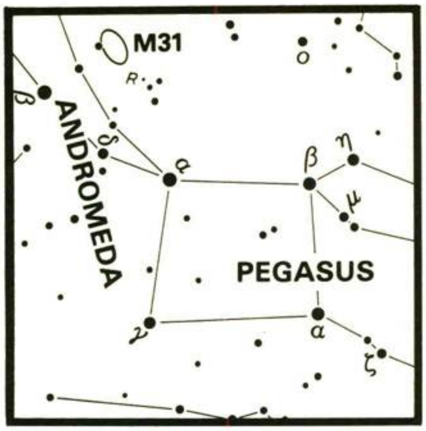
If you look northeast from Alpheratz, you will find two equally-spaced stars in line with it that are of almost the same brightness. They are **Mirach** (Beta Andromedae) and **Almach** (Gamma Andromedae). Follow the line from Alpheratz to Mirach and then turn your gaze northwest. You'll pass two faint stars (visible only with binoculars) and come upon a strange and unmistakably unstarlike glow. This is M-31.

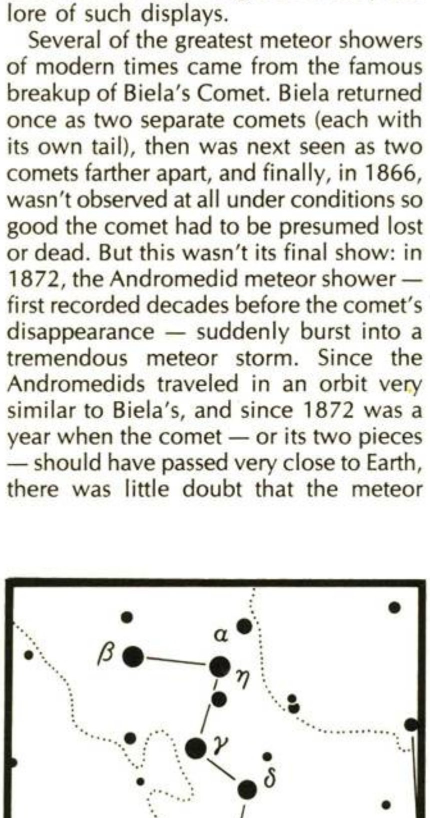
If you turn southeast from Mirach and travel just as far, you'll come upon the much more difficult galaxy **M-33**. If you glimpse M-33 with your naked eye, it's a good indication that you have very dark skies.

Skylore

Meteor storms are made up of hundreds or even thousands of "shooting stars" pouring from a radiant point as we cross a swarm of meteoroids in space. With the remote chance of a great Orionid display and the distinct chance of outstanding Draconid activity, there couldn't be a better month for looking at the history and lore of such displays.

Several of the greatest meteor showers of modern times came from the famous breakup of Biela's Comet. Biela returned once as two separate comets (each with its own tail), then was next seen as two comets farther apart, and finally, in 1866, wasn't observed at all under conditions so good the comet had to be presumed lost or dead. But this wasn't its final show: in 1872, the Andromedid meteor shower — first recorded decades before the comet's disappearance — suddenly burst into a tremendous meteor storm. Since the Andromedids traveled in an orbit very similar to Biela's, and since 1872 was a year when the comet — or its two pieces — should have passed very close to Earth, there was little doubt that the meteor storm came from part of the swarm which had been enhanced by the breakup of Comet Biela.



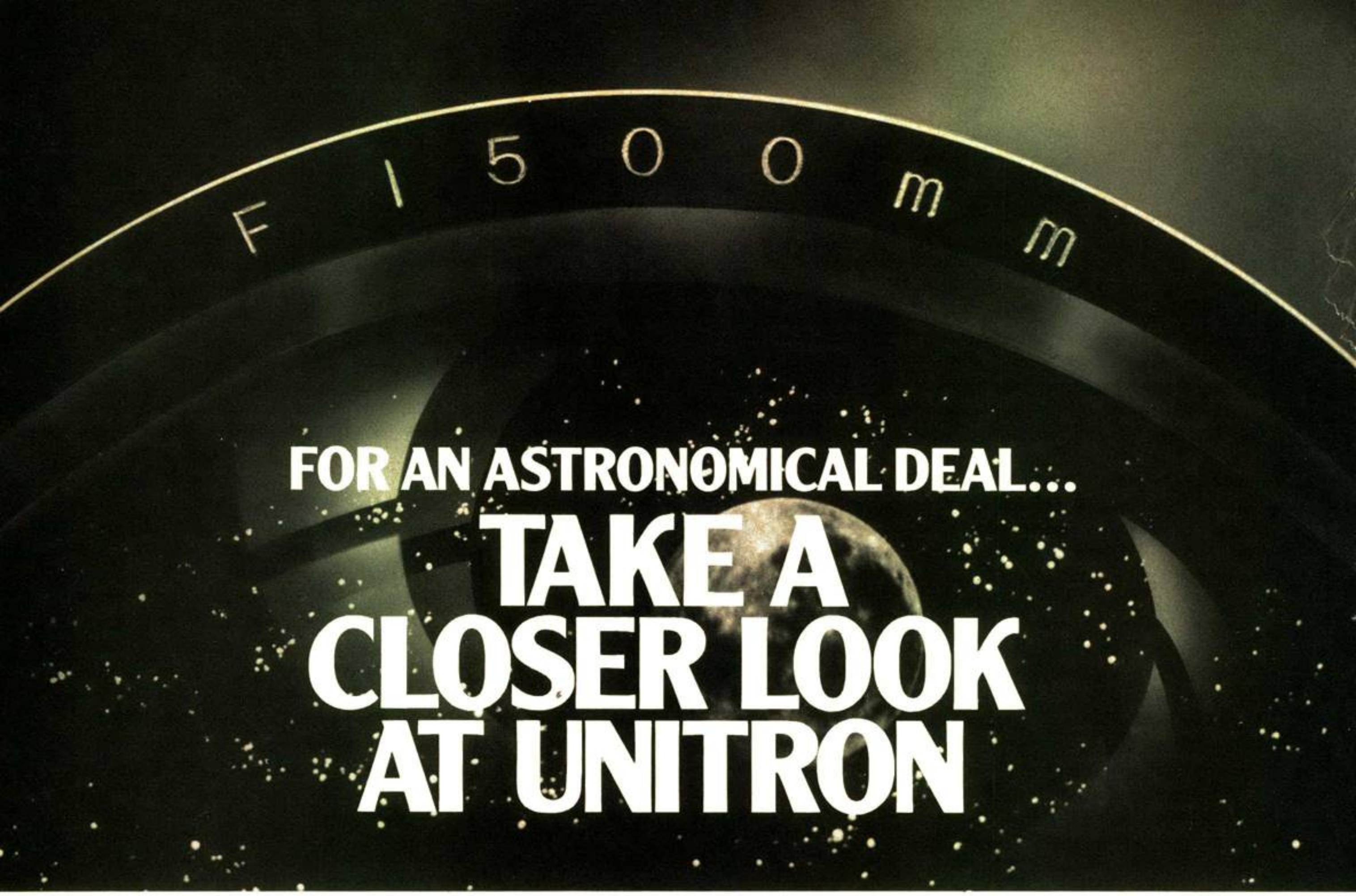


On November 27, 1872, meteorologist E.J. Lowe computed that almost 60,000 Andromedids streaked across his viewing area in five hours; on the same date in 1885, F. Denza and his assistants saw about 40,000 in four hours. Rates as high as 75,000 per hour were supposedly recorded in the latter storm, during which the first meteor photo was taken. After showers of 100 or more per hour in the 1890's, the meteor displays greatly lessened in intensity and Jupiter has now perturbed the swarm away from its old path.

Where the Andromedids left off, however, the Draconids have taken up. They are derived from this year's "other" comet, Giacobini-Zinner. Last month, an American spacecraft passed through the comet's tail not far behind its head; earlier this year, astronomer Zdenek Sekanina published a study showing the comet's nucleus must be a kind of pancake — over eight times wider at the equator than at the poles and spinning so fast that centrifugal force causes all but the poles to be free of surface dust. This evidence suggests that the nucleus could be a chip off some earlier, larger nucleus or, at any rate, on the verge of splitting entirely to pieces.

The Draconids' behavior is consistent with these ideas because they seem to be the most fragile of all meteors and are often faint — though William F. Denning observed a −7 magnitude Draconid fireball in 1926. In 1933, the first Draconid storm filled the skies with as many as 6,000 per hour; in 1946, as many as 10,000 per hour were reported in the southwestern United States — even though there was a Full Moon that evening!

The meteor swarm follows in the wake of the comet; whenever we cross that wake relatively soon after the comet, we experience a Draconid storm. In 1946, we arrived at the point 15 days after Giacobini-Zinner; this year, the interval is less than a month, so we have a distinct chance to see some real activity.



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16503	2.4″ Equatorial Refractor/ Precision Mount	770.00	**55.00**	715.00
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16540	3″ Compact Equatorial Refractor/Precision Mount	1,078.00	**75.00**	1,003.00
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309B	15-40x50mm Rubber Cov'd.—Black	93.50	**6.00**	87.50
309R	15-40x50mm Rubber Cov'd. —Camouflage	93.50	**6.00**	87.50
310B	10-30x30mm Rubber Cov'd.—Black	62.95	**4.00**	58.95
310G	10-30x30mm Rubber Cov'd.—Green	62.95	**4.00**	58.95
310R	10-30x30mm Rubber Cov'd. —Camouflage	65.95	**4.00**	61.95
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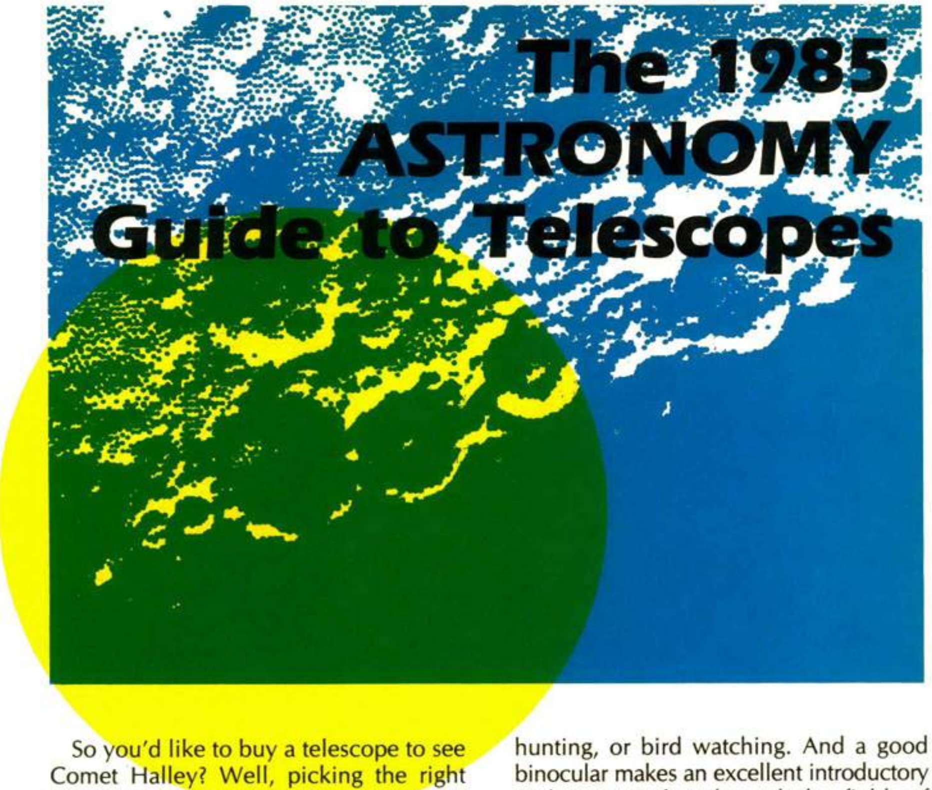
The 1985 ASTRONOMY Guide to Telescopes



So you'd like to buy a telescope to see Comet Halley? Well, picking the right telescope isn't easy. In fact, at times it seems as if there are so many sizes, models, features, and accessories that it's tempting to forget the whole thing and go buy a stereo, VCR, or sailboat instead! But hold on — if too much choice is getting you down, we're here to guide you through the process of choosing a telescope that's right for you.

Well — where should we begin? Oddly enough, the place to start is with *you*. You see, it's your interest in astronomy that determines the best telescope, not the telescope itself. What makes deciding on a telescope so difficult is that you must figure out what you'd like to do and see before you've seen it or done it. In this article, we'll give you some idea of what each of the many types of telescopes can do — and let you be the judge.

One important thing to remember about telescopes — something so obvious it's easy to forget — is that whatever telescope you get, you'll be looking at the same sky. This means you'll be able to see many of the same things with any telescope. Some telescopes are better for seeing some things than others, and that's what we'll be talking about. Basically, though, it means you can get off to a pretty good start in astronomy with any reasonably good scope.

You asked about a telescope for seeing Comet Halley? Well, be patient and we'll get to that in a little bit . . . .

Binoculars

Binoculars? You've *got* to be kidding!

Actually, we're not. A binocular is really two telescopes side by side, a telescope for each eye. Never thought of it that way before? Furthermore, binoculars are easy to use, versatile, and portable. The whole family can enjoy them — for sports, hunting, or bird watching. And a good binocular makes an excellent introductory "telescope" for the whole field of astronomy.

Another big plus is that many people already own a binocular. Is it suitable for viewing Comet Halley? There's an easy way to find out. Somewhere on the instrument, usually just below the brand name of the maker, you'll find some numbers — like 8x20 or 7x35. The first number is the magnification and the second number is the diameter of the big lenses in millimeters. Divide the diameter by the magnification, and you'll get a number called the "exit pupil." If the exit pupil is 5 or larger, the binocular is excellent for astronomy. If it is smaller than 4, the instrument is intended primarily for daytime use, not astronomy. An 8x20 binocular has an exit pupil of 20 divided by 8 equals 2.5 — too small for comet watching. A 7x35 binocular has a 5mm exit pupil, and would be satisfactory.

The most commonly recommended all-around binoculars for astronomy are 7x50s. The famous "night glass" of World War II was a 7x50. As explained above, "7x" is the magnification and "50" refers to the diameter of the binocular lenses. The exit pupil is 7mm. You'll get a bright image and wide field of view well suited for scanning large regions of sky and viewing large diffuse objects — like comet tails. Well-made 7x50 and 10x50 binoculars are larger and heavier than most ordinary binoculars, but you can't beat 'em for stargazing.

Evaluating a binocular is fairly easy. Pick it up, grasp the tubes firmly, and try to wiggle them. There should be no looseness or play. Check that the eyepieces are solidly mounted and move smoothly when you turn the focus knob. Look through them, either across the store or down the street. Are the images crisp and bright or do you see mushy images and funny colored fringes around bright objects? After you've tried half-a-dozen pairs, some good and some not-so-good, you'll be able to spot the differences easily.

When you shop for binoculars, shop for quality rather than price. Of course you'll find cheap units on the market — but inspect them carefully and look at what you don't get. You probably won't find the quality you'd really like for much under $100 list. A binocular should give a lifetime of service. Look for both optical and mechanical quality before making a decision.

How are they for Halley? The answer is "surprisingly good." Binoculars do not have enough magnification or light grasp for watching the subtle details in the head of the comet, but they're perfect for an overall view. They're portable, light, relatively inexpensive, and offer good light grasp and ease in locating faint celestial objects — which is what Halley will be. Astronomers who own a telescope will, almost universally, also use a binocular to observe the comet's tail.

There are so many brand names in binoculars that it's hard to know where to start. Many of the famous name-brand camera manufacturers sell them: Leitz, Nikon, Zeiss, Pentax, and Minolta. Bausch and Lomb, Bushnell, Fujinon, Swift, Steiner, Edmund, Celestron, and Swarovski are also recognized names in the field. Camera dealers, telescope dealers, and sporting goods stores often carry one or more brands.

Big Binoculars

For serious astronomers, there's another binocular option — the BIG binocular. With lenses bigger than 60mm and a magnification greater than 10 times, a big binocular reveals fainter stars and nebulae than ordinary binoculars while still offering the comfort of two-eye viewing and the portability of a binocular. You'll find big binoculars sporting specs of 10x60, 11x70, and 12x80. At appropriately high prices, you can even buy *giant* binoculars — 16x100s and even incredible 25x150s by Fujinon. However, the most practical ones for casual astronomy are the smaller, low-power sizes. Some 70mm and 80mm binoculars feature magnifications of 20, 25, and even 30 times; to determine their astronomical effectiveness, divide the aperture (that's the diameter of the lens) by the magnification to find the exit pupil, just as you do for ordinary binoculars. If the exit pupil is smaller than 4mm, then it's not optimum for astronomy.

For comet-watching, big binoculars are considerably more powerful than ordinary binoculars, but they're still best for looking at the comet as a whole rather than studying the nucleus and coma close up. However, if you already have a medium or large-size telescope and you'd like a nearly ideal instrument for spotting the comet low in murky skies during March and April, a big binocular is your best bet. But big binoculars tend to be heavy — so you'd better plan on buying a sturdy tripod, too.

In the astronomical field, scores of telescope dealers carry the Celestron, Star Flite, and Meade brand-name big binoculars, while a variety of other import big binoculars are available at camera dealers and telescope stores.

Spotting Scopes

So you've been looking at spotting scopes? And you've noticed they're a lot less expensive than astronomical telescopes with the same specs. And now you'd like to know whether it's worth going "the whole nine yards" and getting the astronomical telescope.

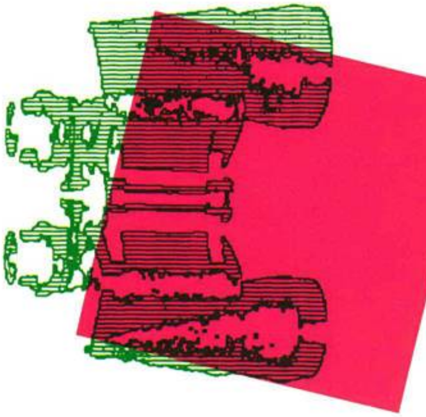
That depends on you. It's probably not worth buying an astronomical telescope if all you want to see is Comet Halley. A good spotting scope will do that well enough. However, if you'd like to sample the whole field of astronomy, a spotting scope probably won't have all the capabilities you'll want.

Spotting scopes are the next step up from binoculars. There are two types common on the market today: lens-type spotting scopes and mirror-lens (catadioptric) spotting scopes. The mirror-lenses tend to be larger and more powerful. Typically, spotting scopes offer an aperture (that is, the diameter of the lens) between 60mm (typical of lens-type scopes) and 100mm (typical of mirror-lens types) with magnifications between 15 and 60 times. Most of them have too high a magnification to use without a tripod — if you try to hand-hold, the shaking of your arms will make seeing anything virtually impossible. If you don't already have a tripod, you'd better plan on ordering one with the spotting scope.

What should you look for in a spotting scope? Especially for astronomy (and comet viewing), you need ample aperture. Spotting scopes with 30mm or 40mm lenses won't give the large, bright views you want. Once again, divide the aperture by the magnification to find the exit pupil. With zoom spotters or those with more than one eyepiece, use the lowest magnification. The exit pupil should turn out to be 5mm or larger for best results. Exit pupils smaller than 4mm at the scope's lowest magnification simply won't do.

Also look for solid construction. Having a look at a few top of the line spotting scopes is a big help. Even if they cost more than you want to spend, check out a few well-made instruments, then try to find the same solidity in your price range. Do things inside rattle when you shake it? Do the eyepieces fit securely? Is the tripod socket heavy duty?

As is the case with binoculars, there are dozens of spotting scope makers — and thousands of retailers. Typical lens-type spotting scopes come from Bausch and Lomb, Steiner, Nikon, Bushnell, and Swift, while Celestron, Edmund, Meade, Zeiss, Swarovski, and Bushnell make the most widely-marketed catadioptric spotting telescopes. You'll find them in camera stores, telescope stores, and sporting goods and hunting stores.



Small Refracting Telescopes

The long white tube atop the tall tripod has often been an amateur astronomer's first telescope. With an aperture between 50mm and 80mm, tube length between two and four feet, and mounted equatorially or alt-azimuth style, small refractors are an excellent introduction to astronomy. The classic instrument is the 60mm (2.4-inch) refractor, a telescope large enough to show lunar craters, Jupiter's satellites and cloud bands, the rings of Saturn, and the polar caps of Mars, split lots of double stars, and even show a few hundred star clusters and nebulae.

Refractors have been with us since Galileo — but Galileo's telescopes were not very good. The lens consisted of a single lens made from one type of glass, and suffered from severe "chromatic aberration" — or color fringing. Achromatic lenses, perfected around the time of the American Revolution, consist of two lenses made of different types of glass. This nearly eliminates chromatic aberration, and the performance of small achromatic lenses approaches perfection.

Yet as recently as five years ago, small refractors were almost extinct. Most of them had been oriental imports; international monetary fluctuations drove their prices so high relative to Newtonian telescopes (see below) that small refractors were no longer a good choice for a first telescope. Curiously, they're coming back as currencies shift and lower the cost of import optics, and as the prices of domestic Newtonians and catadioptric telescopes rise. But something else has happened, too. The best modern imports are well-made, reliable instruments that offer real value to the beginner.

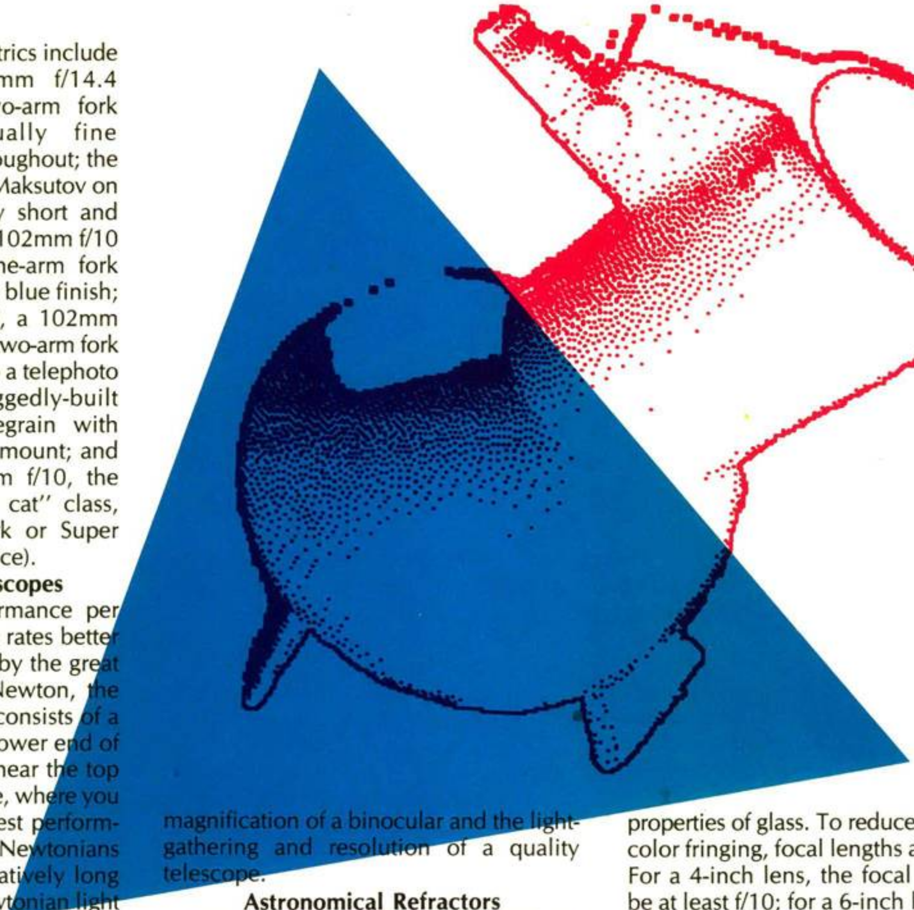
Unlike spotting scopes, which they otherwise resemble, small astronomical refractors come with mounts that allow you to point them toward the celestial object you want to view. Furthermore, you can switch from one eyepiece to another for different magnifications. This allows you to observe the entire disk of the Moon at 40x magnification, for example, then view the sunlit limb at 80x, and finally zero in on a few craters at 150x. Quality brand names include Unitron, Pentax, Celestron, Meade, Parks, and Swift.

Small Catadioptric Telescopes

Small catadioptric (CAT-uh-die-OP-trik) telescopes are those with apertures between 85mm and 125mm — with most at 102mm aperture, or 4 inches. It's not the optical tube assembly that makes the unit an astronomical telescope, it's what comes with it. All are mirror-lens combinations, optical hybrids that combine the best of lens systems and mirror systems. Compact yet powerful, catadioptrics are tops in convenience. Some have Schmidt-Cassegrain optical systems (with a thin corrector plate lens), while others have Maksutov-Cassegrain optics (with thick and deeply-curved corrector lenses).

The mirror-lens optical system consists of a corrector lens (either Schmidt or Maksutov style) at the front of the telescope tube, a primary mirror at the back end of the tube, and a small secondary mirror mounted on the inside of the corrector lens. The light exits the telescope through a hole in the primary mirror and comes out the back of the tube. This folded optical configuration gives a long focal length in a short tube. Catadioptric spotting scopes and astronomical telescopes of the same make usually have the same optical system.

So — what sets the astronomical catadioptrics apart from spotting scopes? Simply this: the telescope is attached to a mounting designed to track the stars. With a built-in drive gear, the mount slowly swings the telescope around to follow the stars. In addition, the telescope may come with two or more eyepieces so you can easily find celestial objects at low magnification, then examine them closely at high magnification.



Outstanding small catadioptrics include the Questar 3½, an 89mm f/14.4 Maksutov system on a two-arm fork mount, featuring unusually fine workmanship and design throughout; the Celestron C90, a 90mm f/10 Maksutov on a one-arm fork mount, very short and portable; the Meade 2040, a 102mm f/10 Schmidt-Cassegrain on a one-arm fork mount with a handsome dark blue finish; the Bushnell Criterion 4000, a 102mm f/10 Schmidt-Cassegrain with two-arm fork mount, readily convertable to a telephoto lens; the JSO-12B, a ruggedly-built 120mm f/10 Schmidt-Cassegrain with optional German equatorial mount; and the Celestron C5, a 125mm f/10, the largest scope in the "small cat" class, mounted on a two-arm fork or Super Polaris equatorial (your choice).

Small Newtonian Telescopes

In terms of optical performance per dollar invested, no telescope rates better than a Newtonian. Invented by the great English physicist Sir Isaac Newton, the Newtonian's optical system consists of a high-precision mirror at the lower end of the tube and a small mirror near the top to direct the image out the side, where you view it. To provide the highest performance at the lowest cost, small Newtonians have spherical mirrors of relatively long focal length. Because the Newtonian light path is not folded back on itself, the telescope tends to be longer than the equivalent catadioptric.

Mounted atop a sturdy tripod with a solid equatorial mounting, a small Newtonian is an excellent first telescope for astronomy. The Newtonian optical system is much simpler than achromatic lens or catadioptric optical systems, and therefore much less expensive than refractors or Schmidt-Cassegrains of the same aperture. However, only a few manufacturers make Newtonians in the "beginner's telescope" aperture range. Edmund Scientific is one: they offer a sturdy 4-inch f/10 Newtonian with an equatorial mount. One important telescope option is to build a small or medium-aperture Newtonian (see below).

In the retail market, Jason/Empire and Tasco offer inexpensive import Newtonians through a variety of nationwide chains and discount outlets. Unfortunately, these stores seldom have knowledgeable sales personnel to demonstrate the equipment or help you in making a sound purchasing decision.

Small Newtonians need not be bulky. Edmund Scientific's unique ball-mounted 102mm f/4.5 Newtonian, the Astroscan 2001, features a short-focus paraboloidal mirror in a cast-plastic tube with a ball on the end. The ball turns in a simple tripod casting; the resulting telescope is inexpensive, easy to use, and offers bright, clear images and wide-field viewing. For viewing Comet Halley, the Astroscan combines the ease of use and low magnification of a binocular and the light-gathering and resolution of a quality telescope.

Astronomical Refractors

For the sheer pleasure of razor-sharp images on a dark velvet-black field, nothing beats a refractor, especially the apochromatic refractors now on the market. Although pretty much confined to the 4 to 8-inch aperture range, refractors generally deliver better images than larger catadioptrics or Newtonians, not only for observing the planets and the Moon, but for double stars, star clusters, and specialized jobs like comet-seeking. The reasons are three: 1) it is easier to produce a super-good optical surface on a lens than on a mirror, 2) the optical system is unobstructed, and 3) the tube is closed, reducing image-disturbing internal temperature variations. Furthermore, it is easier to stop stray light from "fogging" the image produced by a refractor. While experts argue endlessly about how much better refractors actually are, they all agree refractors give the best images.

There are currently three types of astronomical refractor lenses: the classic achromatic doublet, the fluorite doublet lens, and the triplet apochromatic. The terminology is slightly confusing, since achromatic and apochromatic look a lot alike. The "a-" prefix means the lens is "without" color, while "apo-" means "totally free of" troublesome chromatic aberration.

Classic achromatic refractors have served astronomy for over 200 years. An achromat has two glass types (hence is called a "doublet") to partially correct chromatic aberration — but even the best achromats are limited by the physical properties of glass. To reduce troublesome color fringing, focal lengths are kept long. For a 4-inch lens, the focal ratio should be at least f/10; for a 6-inch lens, f/15; for an 8-inch lens, f/20. Achromatic refractors built to these limits perform superbly. Short focal lengths offer greater convenience and portability, but there is no escaping chromatic effects.

Among the makers and importers of achromatic refractors of 4-inch aperture are TeleVue, noted for the handsome 4-inch f/6 Renaissance refractor, Cheshire Instrument Company, makers of a compact 5-inch f/5, and Unitron, Meade, Celestron, Pentax, Edmund, and Parks, marketing conventional long-focus (i.e., between f/10 and f/15) instruments in a variety of apertures. Vernonscope sells a highly-corrected 80mm system. Dobbins Instrument Company, Goto Optical Company, and Carl Zeiss make precision refractors of 6-inch and larger aperture. The Jaegers Optical Company supplies precision refractor lenses, for do-it-yourselfers, in a variety of sizes up to 6 inches aperture and in focal ratios of f/5, f/8, f/10, and f/15. Their lenses enjoy a fine reputation.

Among the doublet, or two-lens refractors, however, there is an exception. Lenses using a very expensive optical material called calcium fluorite have far less residual chromatic aberration than ordinary achromats. Lenses made with fluorite show virtually none of the purple halo of secondary spectrum so characteristic of classic doublets — and because a long focal length is not as necessary to control color, these refractors are usually considerably shorter than comparable achromats. Because fluorite is so expensive, fluorite refractors seldom exceed 4 inches aperture. Leading fluorite refractor brands include Takahashi and Celestron.

Finally, there are the apochromatic triplets, or three-lens designs. Like fluorite lenses, triplet refractors offer near-complete freedom from color, but at lower prices and in larger apertures than fluorite. Apochromats are fully color-corrected at relatively short focal ratios: a 6-inch apochromatic triplet has much better color correction at f/8 than a doublet does at f/15. The only maker of apochromatic triplets is Astro-Physics Corp. with a quality line of 4-inch, 5-inch, and 6-inch apochromats and photo-apochromatic telescopes.

Astronomical Catadioptrics

Catadioptrics are, without a doubt, the most popular telescope made today. By packaging a large aperture (8 inches) in a short tube, the Schmidt-Cassegrain telescope (or SCT) utterly revolutionized amateur astronomy a little over a decade ago. Introduced by Celestron, the marketplace now supports three domestic manufacturers: Celestron International, Meade Instruments, and Bushnell. Furthermore, to the benefit of the comsumer, intense brand-name competition has tended to keep prices low and quality high in these compact and versatile instruments. All three makers offer 8-inch f/10 fork-mounted Schmidt-Cassegrain catadioptrics.

The SCT optical system consists of a thin corrector plate, the primary mirror, and a secondary mirror mounted on the inside of the corrector plate. By folding the optical path inside the telescope, the system packs an f/10 focal ratio into a tube length only twice the diameter of the primary mirror. These instruments are focused by moving the primary mirror, so attaching cameras or other apparatus is greatly simplified.

Full accessory lines are offered for all three brands — eyepieces, star diagonals, solar filters, and the like — plus third-party makers sell everything from sophisticated cameras for astrophotography (Lumicon) to photoelectric photometers (Optron and Thorn-Gencom) for the Celestron, Meade, and Bushnell SCTs.

Until a few years ago, all SCTs were fork mounted. The fork attaches to a drive base with an internal gear for tracking; the base attaches to a latitude wedge, and that, in turn, bolts to a heavy-duty tripod or pier. The optical tube assembly, fork, and drive base are usually sold at a base price, with the latitude wedge and tripod sold separately. Without these "optional" accessories, however, these telescope are difficult to use for astronomy. Nowadays, one manufacturer (Celestron) offers an alternate mount: a computer-controlled German equatorial mounting that automatically moves the telescope from one celestial object to another.

Celestron's SCT line includes the 8-inch aperture Super C8 and Super C8+, both f/10; the 11-inch f/10 C11, and the massive 14-inch f/11 C14. These instruments all include worm gear drive mounts. Meade Instruments' line includes the 8-inch f/10 model 2080 LX3 with built-in quartz drive corrector and the 10-inch f/10 model 2120. Bushnell's line includes the Criterion 6000, a 6-inch f/10 SCT, and the 8-inch f/10 Criterion 8000 SCT.

Catadioptrics include both SCTs and Maksutov-Cassegrains. One major maker, Questar, offers high-quality Maksutov-Cassegrain telescopes. With apertures of 7 and 12 inches, the Questar 7 and Questar 12 have long been the "dream machines" of amateur astronomy. The Questar 7 comes with a compact fork mounting and the Questar 12 on a massive German equatorial.

Newtonian Reflectors

When they need lots of light-gathering power for observing faint nebulae and galaxies visually, most observers immediately think of Newtonian reflectors. This, however, sells the Newtonian design somewhat short. Newtonians have also long been noted for high resolution planetary observing and impressive astrophotographic capabilities at relatively low prices.

Nowadays, there are two types of Newtonians: the classic equatorially-mounted Newtonian and the so-called Dobsonian telescope, actually a Newtonian on a special alt-azimuth mounting. (We cover Dobsonians in the section below.) Both equatorial and Dobsonian Newtonians are well-suited for do-it-yourselfers who want to build their own telescopes because they are simpler than other types of telescopes. Typically, home-builts perform as well as commercial instruments, and offer the amateur astronomer the chance to own a large and powerful telescope. Many firms sell parts and accessories for home-built telescopes.

Newtonian telescopes may be big in capability, but they're also big in size. The elegantly simple two-mirror optical system requires that the tube be as long as the focal length of the telescope, so a 12-inch f/8 Newtonian is actually nearly 8 feet long! Equatorial mounts capable of supporting such large telescopes must be exceedingly solid and are usually quite massive. Obviously, climbing up to look into the eyepiece could be a problem, too. Large Newtonians come with tube rotating rings to allow turning the eyepiece to a comfortable observing position. Despite these apparent drawbacks, large Newtonians work very well as backyard telescopes — especially when the owner can store them in a nearby garage or shed, or cover them with a roll-off shelter. Six and 8-inch Newtonians are generally light enough to carry out easily.

The principal brand names in equatorially-mounted Newtonian telescopes are Parks, Meade, and Celestron. Parks' Newtonians come in 6, 8, 10, and 12-inch apertures on newly-designed medium or heavy-duty equatorial mounts. Meade offers 6 and 8-inch Newtonians for the beginner, and "research grade" instruments in 8, 10, and 12-inch apertures. Celestron offers 6 and 8-inch aperture f/5 Newtonians.

Meade sells two low-price Newtonians, one a 10-inch f/4.5 and the other a 16-inch f/4.5, in the "Deep Space" series, for deep-sky observers; and the Star Liner Company offers a line of equatorial fork-mounted Newtonians, convertible Newtonian-Cassegrains, and custom units up to 24-inch aperture.

Dobsonian Reflectors

The other side of modern Newtonians are Dobsonians. Named after John Dobson of the San Francisco Sidewalk Astronomers, the Dobsonian alt-azimuth design permits amateurs access to very large telescopes — as large as 29 inches aperture. Although the Dobsonian mount cannot automatically track the stars, the design is so smooth that the observer can move the telescope almost without thinking about it.

Big Dobsonians offer, above all else, enormous light-gathering power. They are largely responsible for creating today's bands of deep-sky observers. (These hard-core fanatics have seen deeper into space than their fellow man, studied first-hand the filigree structure of faint nebulae, and viewed the spirals of distant galaxies with their own eyes — and they're proud of it.) Built of cardboard tube and plywood, Dobsonian telescopes offer the greatest light per dollar ratio in the telescope industry. They are, however, quite specialized telescopes, and those above 13-inches aperture are difficult to transport.

However, Dobsonians make good sense in small apertures, too. As a do-it-yourself telescope project, Dobsonians are mechanically simple to build and give good performance when completed. For those who want a finished telescope, Telescopics offers 6-inch f/5 and 8-inch f/5 Newtonian reflectors in natural oak Dobsonian mountings. Coulter Optical is the major domestic maker of Dobsonian telescopes. Their Odyssey line includes the Odyssey 8, an 8-inch f/4.5, a good low-price beginner's telescope; the Odyssey Compact, a 10-inch f/4.5; the Odyssey I, a 13.1-inch f/4.5; the Odyssey II, a 17.5-inch f/4.5, perfect for serious deep-sky observers; and the Odyssey 29, a 29-inch f/4.5 giant suitable for an entire astronomy club. Coulter also sells finished mirrors for amateur astronomers who want to build their own large-aperture Dobsonian telescopes.

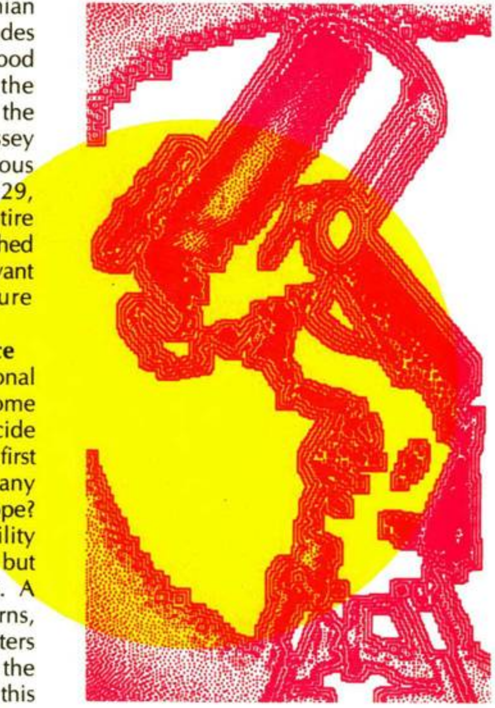
Versatility, Size, Weight, and Price

Getting the right telescope is a personal choice. However, we can offer some broad hints that may help you decide where to concentrate your efforts. The first thing to consider is versatility: how many things can you do with the telescope? Binoculars are tops for overall versatility — sports, hunting, comet watching — but they're not astronomically versatile. A binocular can reveal faint star patterns, pick out a few of the brighter star clusters and galaxies, and help you you view the broad sweeping tail of Halley's Comet this winter. It won't show you planetary or lunar detail, or any of the other jobs telescopes handle so much better. Spotting scopes are also limited to broad, general sky watching. Even the most powerful catadioptric spotters, without a mounting suitable for astronomy, are severely limited — best for "sticking a toe in to test the waters."

Small telescopes — including 60mm refractors, 4-inch catadioptrics, 4-inch f/10 Newtonians, and the Astroscan Newtonian — offer the best of both worlds. They are ideal for beginners in astronomy. Powerful enough to reveal a wealth of lunar detail, features on Mars and Jupiter, the rings of Saturn, star clusters, and some of the brighter galaxies, they can also be used for some spotting, especially serious birdwatching. For a dedicated nature lover who'd like to find out what astronomy is all about, a small astronomical telescope is the best bet — and quite possibly best for Halley, too.

Astronomical telescopes are another ball game entirely — they're getting specialized. Large Newtonian and Dobsonian telescopes triumph for observing deep-sky objects; refractors, especially the long-focus achromats and ultra-perfect apochromats, give great satisfaction to planetary observers. Catadioptrics offer a bit of everything, winning hands-down in easy application to astrophotography, while medium and large-size Newtonians provide the highest performance per dollar ratio and a high degree of versatility. If you're interested in giving astronomy a serious try — and Comet Halley just happens to tickle your interest — then by all means investigate astronomical telescopes.

However, the telescope that will show you everything you want to observe may not actually be the most practical. Powerful astronomical telescopes that are the ultimate for examining the cloud belts of Jupiter or best for seeking out thousands of faint galaxies may be twelve feet long or weigh well in excess of 500 pounds — not to mention the price tag. Somewhere along the line, the physical height, length, and weight of the instrument should become part of your overall assessment. When, where, and how do you intend to observe? Again, don't kid yourself. A backyard telescope must be carried out and set up each time you use it — unless you can leave it out all the time. If you live in the city and have a yen for deep-sky observing, you may have to trek with your telescope in search of dark skies. Will the telescope you're considering fit in: a) your Toyota? b) your Chevrolet Impala? c) your new Vanagon? d) a ¾-ton pickup? e) none of the above? In short: it's better to have a small telescope that you will use than a large one you don't because it's too much hassle.



Finally, there's the price to consider. Only you know how much money a telescope is worth to you, but your family may well have some say in how much money you can spend on it. Unlike the home computer (which you had hoped everybody in the family would use), or the VCR (which everybody does use), telescopes tend to be single-user hardware. In terms of family politics, it might make more sense to get a small telescope in hopes of gaining allies for the cause of backyard astronomy (especially with Comet Halley coming), rather than trying to convince the others to let you make a large expenditure that you alone will enjoy. Amateur astronomy is an infectious interest — but there are those who are immune to the charm of the stars.

Your Local Dealer vs. Buying by Mail

Nowadays most telescopes are boxed at the factory, passed on at wholesale prices to a network of dealers and retail outlets, and offered to the consumer — *you* — at somewhat below full list price. Depending on where you live, you may well have a choice between buying from a local telescope store or ordering from a dealer halfway across the country — at a significantly lower price. How you actually purchase a telescope is your own business, but there are a few things you ought to consider.

First, how much do you know about telescopes? Be honest with yourself. Chances are you wouldn't be reading this article if you felt you already knew all there is to know. Do you really understand enough to buy a telescope with no hand-holding from the seller? If you feel 100% certain that you already know the type, make, and model number of the telescope you want, then you're in a good position to shop for price — and not support. On the other hand, if you need help from the seller to determine what you want, you need to find a knowledgeable dealer.

Second, how do you like to do business? In an ideal world, you'd just go to your friendly local telescope store. You might spend an hour or two talking to a knowledgeable clerk while inspecting a full line of makes and models on display, comparing them for price and performance. It's a difficult decision, but the clerk asks you questions that help you clarify what you want to do with the telescope, and gives lots of helpful advice. Finally, you make up your mind, "Okay, this is the model I think I'd like." The clerk brings a sealed box from the stockroom, and together you open it and inspect the contents. He shows you how various parts fit together and checks that everything is working perfectly. He then helps you repackage the instrument, writes up the sales slip, takes your personal check, and helps you carry the box out to your car. As you drive away, the last words you hear are, "If you find anything that's not right, bring it back and we'll take care of it for you." That's the kind of help that mail-order dealers simply can't offer.

But maybe there *isn't* a telescope store in your town. What then?

Well, fear not — there are superb mail-order telescope retailers who'll deal with you fair and square. It's not hard to tell which ones they are. Just as the clerk in your local store knows his stock and offers good advice, good mail order firms know their stock, too. They'll do their best to help the customer (that's you) long-distance. You'll probably sense the difference right away — they want to make sure you understand what each make and model of telescope can do, and which is best for you.

Fourth, are you sure you know what you're actually buying? Model numbers, for example, can be confusing. In the hypothetical Super-Duper 1000 line of telescopes, the model 1024 is a telephoto lens with a camera adapter, the model 1022 a spotting scope with one eyepiece, and the model 1020 is the telescope with fork mount, drive, three eyepieces, and carrying case. If you want the model 1020 telescope, make sure you haven't been quoted the price of the model 1024 telephoto, or a stripped-down model 1020 *without* eyepieces or carrying case. Furthermore, ask the dealer specifically what is included and what is not — don't just go by the picture in the ad. Then ask for a letter confirming what's included in the price you've been quoted. A reputable dealer may grumble about spending the time to write a letter to you, but he or she will not refuse to comply. And don't send your check or money order (or offer your credit card number) until you receive the letter and have read it. Don't find out too late that the too-good-to-be-true price you've seen advertised really was.

On delivery times, you should be aware that the Federal Trade Commission protects you as a mail order buyer. You have the right to expect delivery within 30 days (unless otherwise specified), and have the right to get your money back — all of it — if the merchandise is not delivered. Although the demand for telescopes during Comet Halley's appearance is likely to produce back-order problems for telescope dealers, there should be no delay if a dealer actually has the telescope you have ordered in stock. Ask before ordering, and get the delivery time specified in writing — along with the price. It might not hurt to check the dealer's reputation with his local Better Business Bureau, especially if you're ordering from a distant big city.

One final hint: "Return within 5 days for full refund" may mean that the equipment must be *back in the dealer's shop* within the specified number of days. If you're not satisfied with your purchase, return it "certified" with "return receipt requested" or via a carrier with whom you can verify the date of delivery — and insure your parcel. *Caveat emptor*!

Buying a telescope nowadays is a lot like buying all hi-tech consumer products — computers, VCRs, cameras, and the like. It's easy to find outlets, but it's hard to find a really good salesperson. If you don't know what you want, you owe it to yourself to do a little research before buying. And when you find a company that deals openly and fairly with you, stick by them, even if it means paying a little more.

Do-It-Yourself Telescopes

In this age of marketing, it's easy to forget an important telescope option: you can build your own telescope. Amateur telescope making got its start in America in 1921, when Russell W. Porter wrote an article for *Scientific American* entitled "The Poor Man's Telescope." In it, he showed how anyone could grind and figure the mirror for a Newtonian telescope to start a lifelong hobby observing the stars. In the decades that followed, thousands of men and women from all walks of life followed Porter's lead. Telescope building enjoyed its heyday in the boom years following World War II. Indeed, many of today's leading telescope companies were founded by do-it-yourself telescope builders in the '50s and '60s.

The way to begin building a telescope is to first find out what's involved. There are quite a few books on telescope making, plus, of course, *Telescope Making* magazine, published by AstroMedia. Three recent books offer the best help for would-be telescope makers. *Build Your Own Telescope* by Richard Berry offers the beginner complete plans for five telescopes, plus lots of pictures showing exactly how to put everything together. *How To Make a Telescope* by Jean Texereau stresses precision optical work, including sections on optical windows, Cassegrain telescopes, and even a computer program for reducing optical test measurements. *Standard Handbook for Telescope Making* by Neale Howard tells how to grind a mirror and build an 8-inch Newtonian reflector. All the parts and supplies you would need to build a telescope can be purchased from companies which advertise in ASTRONOMY.

Of course, building a telescope is much more work than buying one, but there are compensations. There's a lot of satisfaction in constructing a fine instrument, and a lot of satisfaction in studying tiny lunar craters, gazing at the rings of Saturn, or seeing a distant spiral galaxy in a telescope you've made with your own hands. And you'll save money, too.

Accessories

No matter what kind of telescope you buy or build, it probably won't be long before you'll want a few "extras." Maybe you'd like a higher magnification eyepiece — and a lower magnification, too. And a camera adapter to hook onto your camera for astrophotography, then a drive corrector and a guiding eyepiece to make long exposures, and a more powerful finder telescope to aid you in searching out faint galaxies. The list could go on and on — but hold it! It makes sense to slow down and become familiar with your new telescope before investing in every doodad, gadget, and gizmo that can hitch a ride on the sale. Besides — if you get it all at once, what's left to hope for? Half the fun comes from thumbing through telescope catalogs and dreaming about what to order next!

What's Best for You

Oh yes, you were asking about a telescope for Comet Halley? Wonderful. Halley will be lots of fun to see — but don't let Halley alone determine what telescope you get. There's a lot more in the sky to see than just one comet. Think of the whole universe — after Halley . . . .

— *Richard Berry*

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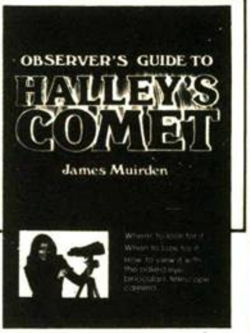

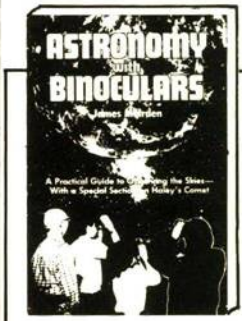

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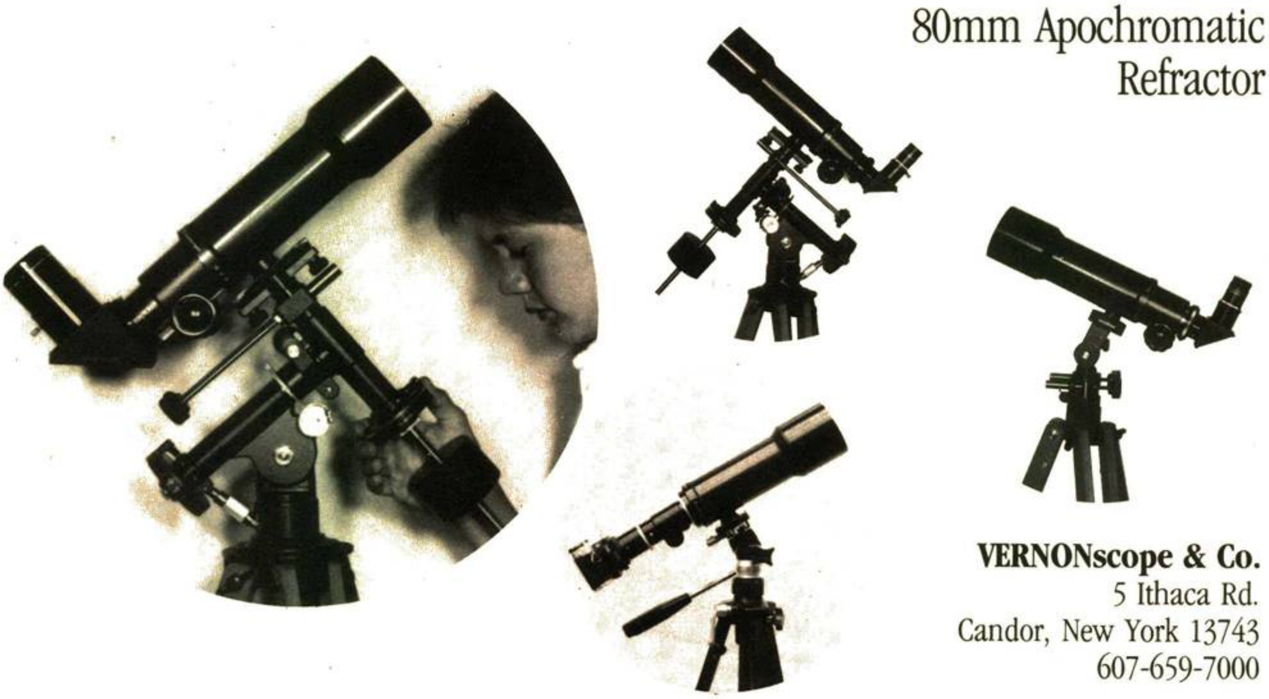

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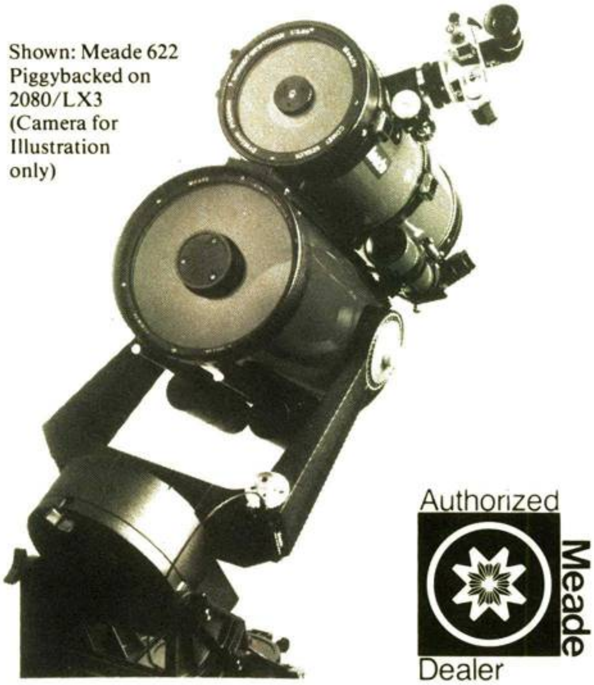

Shown: Meade 622 Piggybacked on 2080/LX3 (Camera for Illustration only)

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ASTRONOMY
Reviews

This month, Astronomy Reviews departs from its usual format to survey some of the printed "Halleyana" that's appeared in the past year or so.

It would be nice to claim we've seen everything, but it simply isn't true — anyone determined to make a full collection of Halley stuff has an enormous job ahead of him. We hope to cover the remainder of this year's Halley books in a second installment.

To begin, let's take a look at two bibliographies. First is **Halley's Comet; A Bibliography** by Ruth Freitag (555 pages, hardcover, $26; U.S. Government Printing Office, Washington, DC 20402). I can't imagine anyone with more than a casual interest in the comet not wanting access to a copy. It's a "finding list," arranged alphabetically by author, for more printed Halleyana — songs, cartoons, articles, books — than you could absorb in months. It's the kind of book to take to a very large library on a rainy day: you'll emerge only when kicked out for the night, and the world of 1985 will look and sound a little strange for a while.

The second bibliography is **Halley's Comet, 1755-1984** by Bruce Morton. Also in hardcover, this 280-page book costs $35 (Greenwood Press, 88 Post Road West, Westport, CT 06881). Morton focuses on the comet's "socio-bibliographic" aspects starting with the return of 1759. He lists such items as John Wesley's *Serious Thoughts Occasioned by the Earthquake at Lisbon* (1755), in which Wesley worries about what would happen to Earth if the comet were to strike, and Ben Franklin's similar speculations in his 1757 almanac, *Poor Richard Improved.* (Neither item appears in Freitag.)

Which to choose? I suppose I'd get Freitag's if I bought just one. It has considerably more entries (3,289 versus 1,301) and is cheaper. On the other hand, each item in Morton's is annotated and the book's chronological arrangement groups the material as it actually was published. Both books are handy.

Halley's Comet, 1910: Fire in the Sky by Jerred Metz (124 pages, paperback, $6.95; Singing Bone Press, P.O. Box 1650, St. Louis, MO 63188) is what you might have compiled on your own had you taken Morton or Freitag's bibliography to a good library and rummaged exhaustively. He quotes from many newspapers, periodicals, books, and advertisements to recreate the experience of the 1910 return. It's ideal for anyone who likes mental time travel.

Some Halley guidebooks concentrate heavily on observing while others are more for "armchair" observers and mainly tell you about comets. Falling into the latter camp is Terence Dickinson's **Halley's Comet; A Mysterious Visitor from Outer Space** (125 pages, hardcover, $8.95; Edmund Scientific, 101 E. Gloucester Pike, Barrington, NJ 08007), written for a general audience. Nine chapters tell about watching for the comet, famous past comet discoverers, space missions to Halley, and so on. The book finishes with a chapter on equipment for viewing and photographing the comet.

In the observing category is **Halley's Comet!** by Francis Reddy (60 pages, large-format paperback, $9.95; AstroMedia, P.O. Box 92788, Milwaukee, WI 53202). The text describes comets in general, Comet Halley's history, the probes being sent to it, and so on. The book focuses on looking for the comet, and provides star-and-comet finder charts for latitudes 55° north, 40° north, and 35° south, along with the best times to observe. The book is wire-bound and the maps are printed on heavy stock.

Also aimed at observers is James Muirden's **Observer's Guide to Halley's Comet** (75 pages, paperback, $3.95; Arco Publishing, 215 Park Avenue South, New York, NY 10003). Besides the usual sections on comet facts, Muirden provides several all-sky finder charts and a month-by-month log from December 1985 to June 1986. The constellation maps with the comet's positions are small (3x4 inches, average), but shouldn't give anyone familiar with a celestial atlas any problems in use. Comet positions are plotted at three or four day intervals.

Capitalizing on its reputation as the country's "newspaper of record," four staff science editors and writers have written **The New York Times Guide to the Return of Halley's Comet** (244 pages, paperback, $7.95; Times Books, New York, NY 10022). It runs the gamut from Edmond Halley's first observations of the Comet of 1682 to the equipment you should have to observe with on this return. There's a wonderful appendix which "covers" the last apparition with stories from the *Times* in 1909 and 1910. This book is certainly one of the best of the crop, despite its lack of finder charts and scanty coverage on observing.

Strong graphics is the forte of Ben Mayer's **Halley's Comet Finder** (77 pages, paperback, $5.95; Perigee Books, 200 Madison Avenue, New York, NY 10016). Although Mayer tells you the basics about comets, the thrust of the book is observational. Using a "starframe" — a re-bent coathanger painted white — for a direction finder, the reader is introduced to the constellations the comet will pass through. The book includes photographic star charts showing the comet's path and logbook pages on which to record your visual and photographic observations. Mayer gives much more on astrophotography (tripod and piggybacked) than most other comet books provide.

Donald Tattersfield's **Halley's Comet** (164 pages, hardcover, $12.95; Basil Blackwell Inc., 432 Park Avenue South, New York, NY 10016) seems mainly for the armchair observer, despite a section on making a simple Haig mount for astrophotography. A major feature of the book are several short BASIC programs that show elliptical orbits (Halley's included), tell when the Moon will interfere with observing, and so on. The programs are for the BBC Model B, and the Sinclair Spectrum and ZX-81 — three British computers of which only the last is likely to be found over here.

The Comet Book by Robert Chapman

and John Brandt (168 pages, paperback, $14.95; Jones and Bartlett Publishers, 20 Park Plaza, Boston, MA 02116) is written by two of NASA's professional comet scientists. It's a very good popularization of the same authors' *Introduction to Comets* and, although not an observer's guide, is the general reader's best compendium of comet facts. Indeed, if you're looking for a basic reference book on comets, this is it.

David Ritchie's **Comets, the Swords of Heaven** (256 pages, paperback, $8.95; New American Library, 1633 Broadway, New York, NY 10019) has a melodramatic title that conceals a good general work on comets. It's aimed at more of a lay audience than Chapman and Brandt's book, but tells its story interestingly.

The International Halley Watch has published two very useful observing guidebooks: **The Comet Halley Handbook; An Observer's Guide** by Donald Yeomans and the IHW **Amateur Observers' Manual for Scientific Comet Studies** by Stephen Edberg. The *Handbook*, a 44-page pamphlet, is now in its second (1983) edition. It provides a few simple all-sky finder charts (which some other books have reprinted) and a day-by-day ephemeris listing comet positions, distances from Earth and Sun, estimated magnitude, and so on, from August 8, 1984 through May 4, 1987. It is available from the U.S. Government Printing Office for $4.75.

The *Amateur Observers' Manual* is about 200 pages long and is available in two volumes from the Government Printing Office for $9 and in a one-volume edition from Enslow Publishers (Box 777, Hillside, NJ 07205) for $9.95. Apart from different bindings, the two editions are identical. The *Manual* contains two parts: part one deals with methods of observing Halley (for example, astrometric photography, visual observation, spectroscopy, meteor watching) and part two reprints the *Handbook* ephemeris and plots the positions at daily intervals on a series of star charts. The plotted positions run from November 1, 1985 to May 30, 1986. It gathers more material on backyard comet observing than any other work I've seen — and the price is very good, too.

A short guide to observing is Garry Stasiuk and Dwight Gruber's **The Comet Handbook** (33 pages, paperback, $5; Stasiuk Enterprises, P.O. Box 12484, Portland, OR 97212-0484). It contains basic information about comets and Edmond Halley; the core of the work is an observing calendar that runs from October 1985 to May 1986. Stasiuk and Gruber also give advice on using and buying binoculars and telescopes and on photographing the comet. A small but useful pocket guide.

Rather in the same vein is **Mr. Halley's Comet** from the editors of *Sky & Telescope* (32 pages, paperback, $2; Sky Publishing, 49 Bay State Road, Cambridge, MA 02238-1290). In humorous drawings, old Edmond himself is shown using his fist to gauge angular distances, scorning a "500x!!" telescope, and taking a tripod photo of his comet. The book includes simple finder charts and a section on the spacecraft missions.

A short pamphlet devoted solely to photography is **Photographing Halley's Comet** (18 pages, paperback, £2.50; Space Frontiers Ltd., 30 Fifth Avenue, Havant, Hampshire PO9 2PL, England). In question and answer form, it outlines the basics of celestial photography — tripod, piggybacked, and guided.

NASA's Goddard Space Flight Center has published **Comet Halley Returns**, subtitled "A Teachers' Guide 1985-1986" (NASA EP-197; 41 pages, paperback, $2; U.S. Government Printing Office). The first part briefly explains the nature of comets and the second outlines student activities for the classroom and outdoors. It includes a BASIC program which gives an ephemeris for the comet.

The Astronomical Society of the Pacific took five articles on comets from its popular magazine *Mercury*, added some extras on observing Halley, and created

CometoN

The Return of Halley's Comet (36 pages, paperback, $4; A.S.P., 1290 24th Avenue, San Francisco, CA 94122).

For anyone interested in the stories behind the discovery of comets and descriptions of their apparitions, Gary Kronk provides details on more than 650 of them in **Comets: a Descriptive Catalog** (331 pages, paperback, $22.50; Enslow Publishers); the dates span from 371 B.C. to 1982 A.D. For example, 1910's "Great January Comet" (1910 I) — often confused with Halley's Comet — was discovered in the morning sky by workmen at the Transvaal Premier Diamond Mine in South Africa. After about two weeks of observation, the comet moved into the evening sky and became very bright. Seen worldwide for a short while, it fell below naked eye visibility by early February and vanished totally by mid-July. It'll be back in about 4,000,000 years!

We have one last item, perfect for cloudy nights — **The Tale of Halley's Comet** by Charleen Catt Lyon (32 pages, paperback, $2.95; Niota Press, P.O. Box 23064, Cincinnati, OH 45223). As the title hints, it's the story of the appearances and eventual discovery of what's now called Halley's Comet. About half text and half pictures, the book offers a wonderful way to spend a cloudy evening. The only snag is that you'll probably have to steal it away from your five-year-old — it's a coloring book. Be a sport, though: if you get the popcorn and cocoa ready, she'll provide the Crayolas. (And remember, both of you keep within the lines!) *Robert Burnham.*

Secrets of the Sun

Ronald Giovanelli
116 pages, hardcover, $19.95
Cambridge University Press (1984)

Approximately five billion years ago, a colossal tenuous cloud of interstellar dust and hydrogen gas began to swirl and contract. Coalescing slowly, the cloud became denser and hotter as its gravity traded size for heat. The cloud eventually transformed into a globe of seething gases. Pressure and heat at its center increased to such an extent that thermonuclear ignition occurred, converting hydrogen gas into helium and releasing vast amounts of energy. Such was the birth of the Sun.

Five billion years later, our star is about a third of the way through its life cycle. Despite its (astronomical) proximity, the Sun has kept a tight hold on many of its secrets — but giant strides toward understanding it have been made in recent decades.

Secrets of the Sun is a comprehensive, authoritative account of what is presently known about this star. Ostensibly written for non-specialists and non-scientists, the book nevertheless requires close attention on the part of the reader and anyone new to astronomy will probably find the going hard.

The author — a leading solar expert who died shortly before the book was published — takes us on a grand tour of the Sun. A fascinating peek into the star's interior helps explain much of what can be seen and detected on the surface. Dissecting the Sun like a biologist, Giovanelli describes the convection zone, solar rotation, the star's heating mechanism, flares, prominences, the corona, the entire chromosphere, and the massive magnetic field which is central to all of these.

Probably the best known solar features are sunspots — they're also easy for backyard telescope owners to observe. The author examines them in detail, explaining their origins and dynamics, and the impact they may have upon Earth. The reader is treated to major ideas and suppositions about them beginning with William Herschel's (who thought them to be windows for the cooler regions below, which were inhabited by "solarians") up to the work of Jack Eddy and other noted solar astronomers today.

The book contains over a hundred high-resolution black and white photographs,

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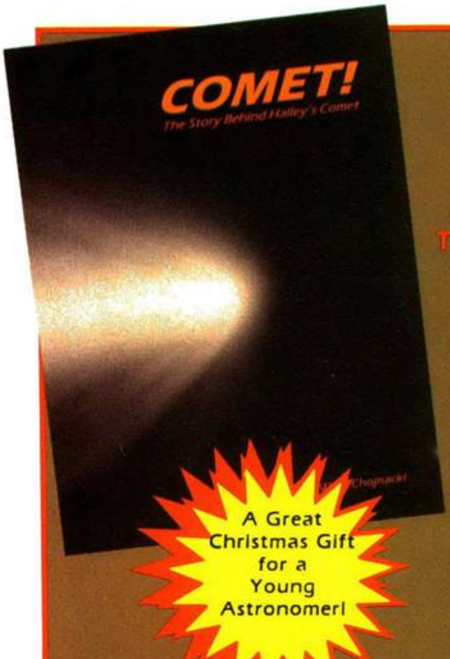

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The author is associate editor of **Odyssey**, the young people's magazine of astronomy and outer space — from AstroMedia, of course!

To order, use the AstroMedia order form bound into this magazine, or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202. Allow 6-8 weeks for delivery.

16 color plates, and numerous charts and diagrams. It depicts the Sun as a place of seething magnetic flux tubes, looping arches of incandescence, and granules and fibrils which play and cavort in unending variety.

The author also sprinkles the text with interesting sidelights and anecdotal information. Our planet, for instance, is technically immersed within the Sun's outer atmosphere. The light and heat received by Earth now was radiated from the Sun's surface 8 minutes ago, but began its journey deep within the center of the Sun over a million years ago.

In his final chapter, "Sunspots and the Weather," Giovannelli tackles a controversial topic. Solar physicists generally doubt that sunspots affect terrestrial weather, but many laymen think otherwise. The author believes there *is* "a very definite, positive" link between terrestrial weather and our star, and he bolsters his argument with information gleaned from as far back as 5500 BC.

The only fault with this otherwise splendid volume is its lack of an index. The book is good, but not easy. Read it, however, and you'll find yourself on fairly intimate terms with our Sun. *Gail O. Clark.*

Physics of Thermal Gaseous Nebulae
Lawrence H. Aller
350 pages, hardcover, $49.50
D. Reidel (1984)

A technical volume and part of Reidel's "Astrophysics and Space Sciences Library," this work provides exhaustive information about the physics of bright nebulae.

Astronomy from Stonehenge to Quasars
Michael W. Friedlander
589 pages, hardcover, $30.95
Prentice-Hall (1985)

An introductory college text that covers the Sun, planets, stars, and galaxies — including sections on cosmology, life in the universe, and quasars.

The Geology of the Terrestial Planets
Michael H. Carr *et al.*
317 pages, hardcover, $16
NASA (1984)
[Order as NASA SP-469 from U.S. Government Printing Office, Washington, DC 20402]

This book takes the terrestrial planets in solar system order and discusses each according to a general formula: orbit, magnetic field (if any), surface characteristics, craters, tectonics, and so on, summarizing what has been learned since 1962. It includes maps, photographs, geological cross sections, inferred stratigraphic sequences, and actual ages where known. The book is intended for the interested layman.

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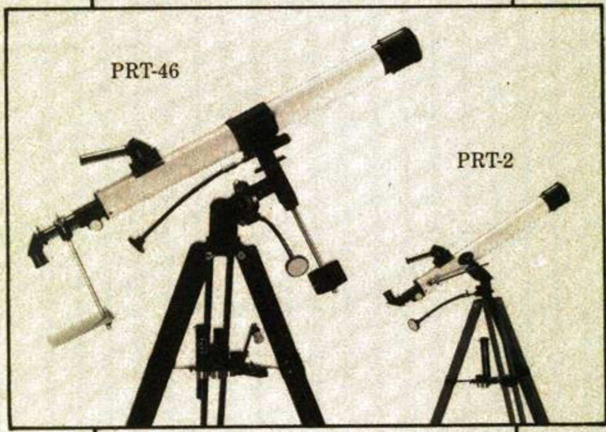

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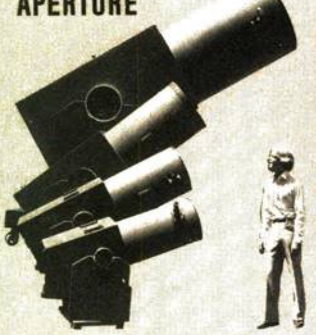

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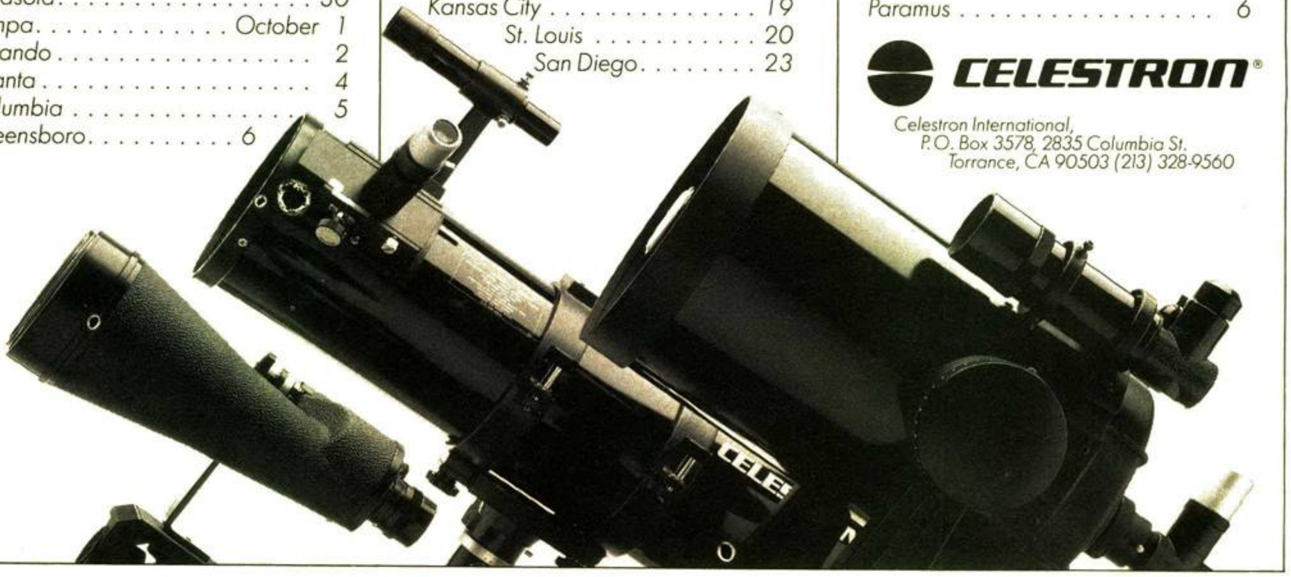

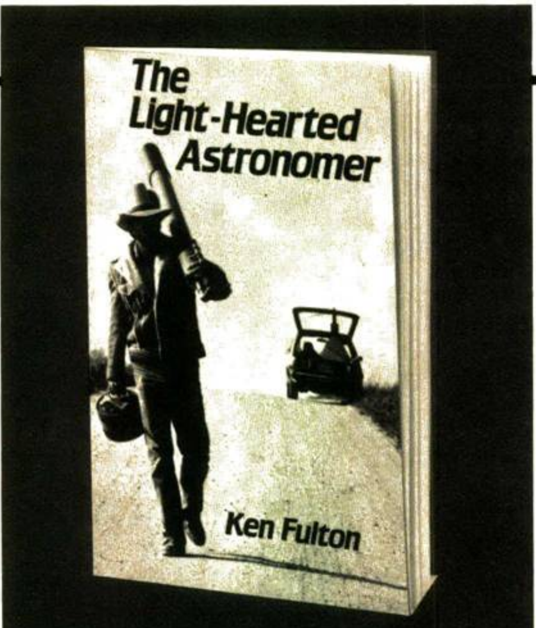

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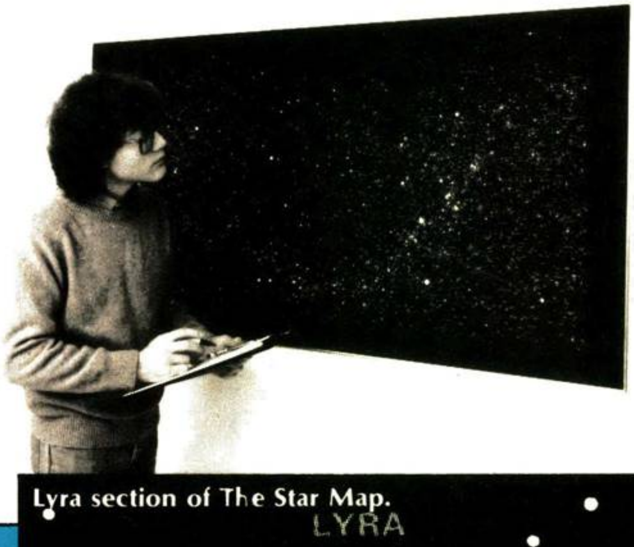
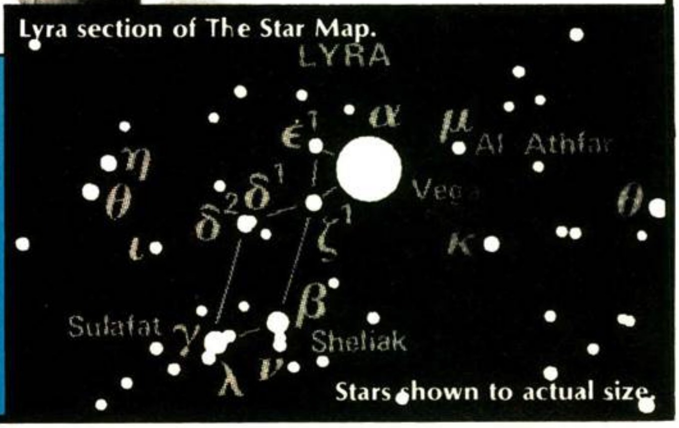
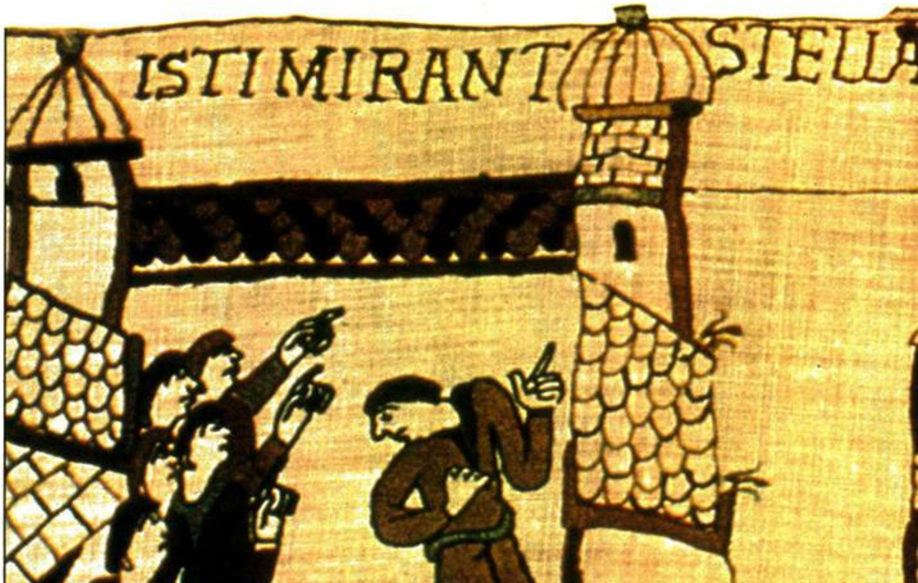



Lyra section of The Star Map.

Stars shown to actual size.

A Halley Chronicle

by
John E. Bortle



For all the printer's ink and paper spent on Halley's Comet over the past two hundred years, precious little has dealt with what Halley looked like at its previous apparitions. One or two of the better returns have been written up, but there's no coherent, detailed overview. Therefore, I thought it might be fun to roll the clock back and see what our great-great^{nth} ancestors saw each time Halley came sweeping out of the night and into *their* sky.

I've consolidated a lot of material into 29 "chapters," each briefly detailing one of the comet's returns. I've also included an ephemeris (1950.0 epoch) that will let you plot the comet's paths on a star atlas. (Don't worry about the difference between the "standard" comet epoch of 1950.0 and the 2000.0 used in most current atlases — it won't amount to much.) With the exception of the 1835 and 1910 figures, which are based on my own calculations, the ephemerides are the work of Dr. Donald Yeomans of the Jet Propulsion Laboratory. The orbital elements they are based on come from a 1981 study of Halley's motion as far back as 1404 B.C. that was done by Yeomans and T. Kiang.

Besides right ascension and declination, the ephemerides tell you how far Halley was from the Earth (d) and the Sun (r) in astronomical units, the elongation from the Sun (e) in degrees, and the "retrodicted" total magnitude (mag).

239 B.C.

According to the *Shih Chi* and *Wen Hsien Thung Khao* chronicles, "During the seventh year of Chih Shih-Huang a comet first appeared in the north and during the fifth month [June] it was seen again in the west."

Based on the ephemeris, Halley's Comet would have first become detectable low in the morning twilight during the third week of May, moving northeastward out of the constellation of Aries. The comet was nearest the Sun on May 25th and was visible almost all night, every night, as it traversed Perseus, Auriga, and Lynx. Shining at perhaps zero magnitude, the comet's long tail would have pointed toward the Pole Star. It was probably about this time that the Chinese first noted the comet's presence. Later, in June, it became an evening object situated in Leo, slowly approaching the celestial equator and fading. This scenario corresponds closely enough with the Chinese account to make it fairly certain that the 239 B.C. observations are of Halley's Comet.

239 B.C.

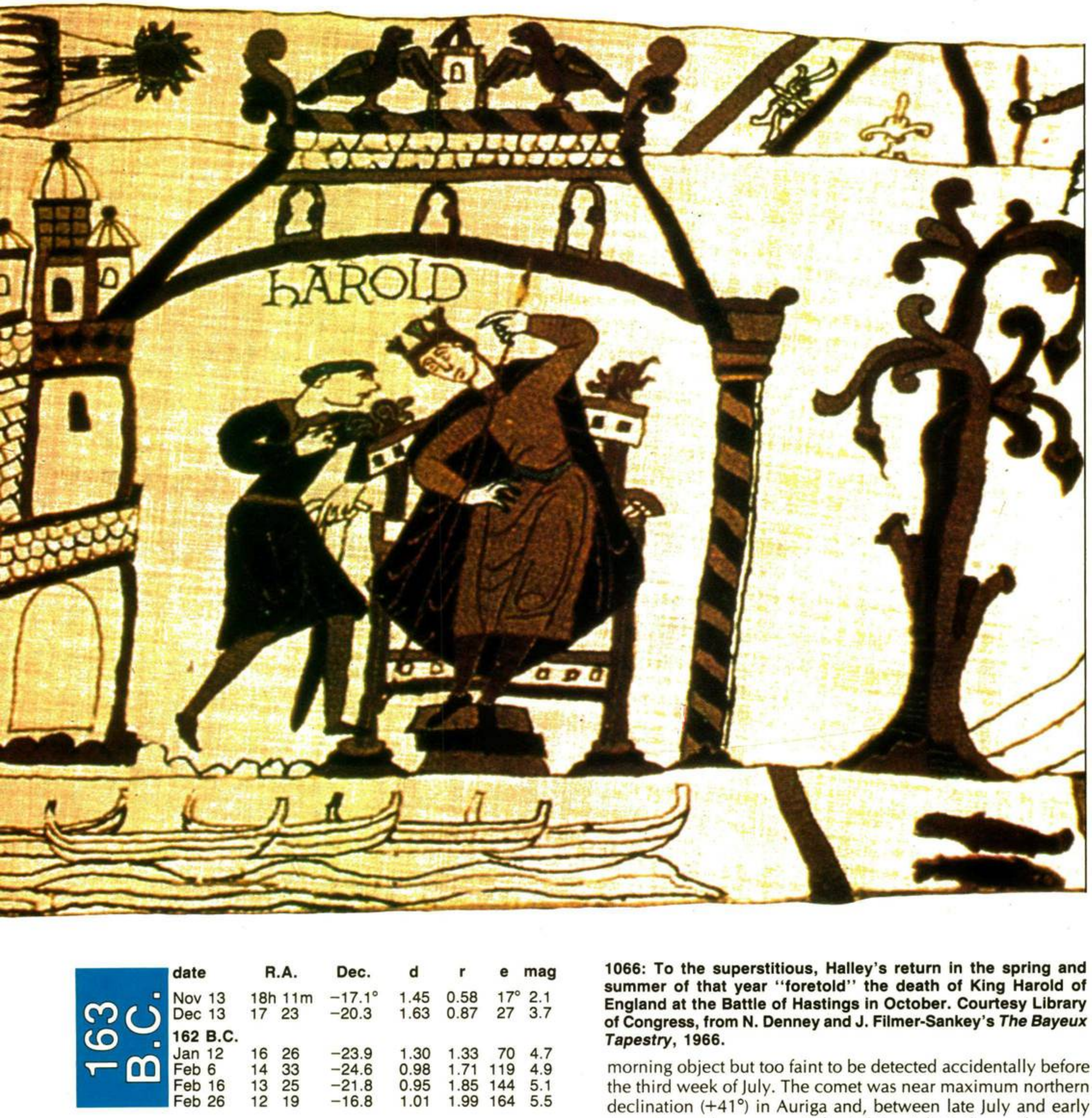
date	R.A.	Dec.	d	r	e	mag
May 21	03h 01m	+29.8°	0.80	0.59	36°	2.5
May 31	05 29	+43.6	0.49	0.60	23	1.3
June 5	08 04	+41.4	0.46	0.63	25	0.9
June 10	09 52	+29.6	0.55	0.68	39	0.5
June 20	11 09	+13.5	0.89	0.81	50	2.1
June 30	11 33	+06.5	1.26	0.95	48	3.5

163 B.C.

Halley's Comet next reached perihelion on November 12, 163 B.C. However, there's no corresponding account in oriental records for a comet observed near this date. The only object recorded around the time was one seen by the Chinese in February, 162 B.C. The single-line entry reads: "On a jen-yin day in the first month of the second year of the later reign-period of Hsiao-Wen [February 6, 162 B.C.], a star with a pointed tail appeared in the southwest."

On that date, Halley had already receded to a distance of 1.7 astronomical units from the Sun and was about 1 AU from Earth. Most authorities regard the 162 B.C. object as unrelated to Halley, and not without reason. Halley's Comet, although well-placed throughout January in the same part of the sky and brighter as well, apparently went unreported.

While I tend to agree there is little likelihood that the 162



1066: To the superstitious, Halley's return in the spring and summer of that year "foretold" the death of King Harold of England at the Battle of Hastings in October. Courtesy Library of Congress, from N. Denney and J. Filmer-Sankey's *The Bayeux Tapestry*, 1966.

163 B.C.

date	R.A.	Dec.	d	r	e	mag
Nov 13	18h 11m	−17.1°	1.45	0.58	17°	2.1
Dec 13	17 23	−20.3	1.63	0.87	27	3.7
162 B.C.						
Jan 12	16 26	−23.9	1.30	1.33	70	4.7
Feb 6	14 33	−24.6	0.98	1.71	119	4.9
Feb 16	13 25	−21.8	0.95	1.85	144	5.1
Feb 26	12 19	−16.8	1.01	1.99	164	5.5

B.C. comet was indeed Halley, a later event hints at a possible link. During its 1835-36 return, with Halley at about the same solar distance, the comet suddenly brightened greatly and then faded. If a similar outburst occurred around February 6, 162 B.C., Halley could have brightened from fourth to first magnitude. Was this the event observed and recorded by the ancient Chinese?

86 B.C.

The 86 B.C. return of Halley was long regarded as the earliest apparition that we could identify with certainty. However, the description this identification is based on is hardly better than that of the 239 B.C. appearance. The *Thung Chien Kang Mu* simply reports, "In the autumn during the second year of the Hou-Yuan reign-period [August, 86 B.C.], a comet appeared in the east."

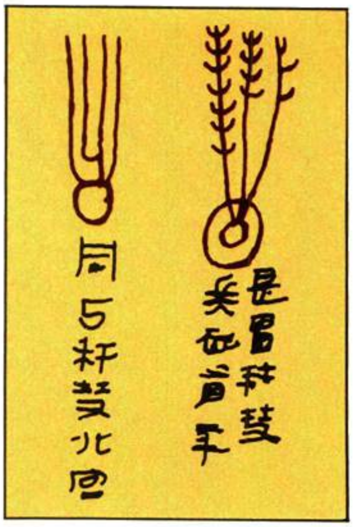
In the summer of 86 B.C., Halley's Comet was initially a morning object but too faint to be detected accidentally before the third week of July. The comet was near maximum northern declination (+41°) in Auriga and, between late July and early August, must have presented a striking sight in the northeastern morning sky. This display was short-lived, however — as the comet entered the evening sky, it quickly became poorly placed for observation and disappeared into the twilight.

86 B.C.

date	R.A.	Dec.	d	r	e	mag
July 23	08h 03m	+38.7°	0.49	0.67	34°	1.9
July 28	10 24	+33.1	0.44	0.62	22	1.4
Aug 2	12 08	+19.7	0.52	0.59	27	1.5
Aug 12	13 24	+02.8	0.88	0.60	36	2.4
Aug 22	13 42	−03.8	1.26	0.68	32	2.4
Sep 1	13 47	−07.2	1.60	0.80	25	3.4

11 B.C.

Throughout history, a comet's sudden appearance has usually been invoked as a precursor of all manner of evil. Halley's



From a 900-year-old tomb in China came a book with representations of some 29 comets, their names, and astrological implications. These two comets were supposed to predict large crops and years of warfare! Redrawn from the Ma Wang Dui Silk Book.

Comet is no exception and has garnered perhaps more than its share of associated bad omens. The oldest omen we have record of dates from the 11 B.C. apparition. It was believed that this return of the comet foretold the death of the great Roman general and statesman Marcus Vipsanius Agrippa. This story is mentioned by the historian Dio Cassius, who stated a comet was seen suspended over the city of Rome before Agrippa died. Observation period: August 26th to October 21th.

11 B.C.

date	R.A.	Dec.	d	r	e	mag
Aug 27	06h 23m	+26.6°	0.57	1.09	83°	4.7
Sep 6	08 40	+39.1	0.22	0.94	67	1.8
Sep 11	13 39	+26.5	0.17	0.86	34	0.9
Sep 21	16 22	−06.0	0.49	0.73	44	2.4
Oct 1	16 39	−11.9	0.88	0.63	39	2.9
Oct 11	16 36	−14.4	1.24	0.59	28	3.4
Oct 21	16 27	−16.1	1.52	0.63	16	3.5

It's little wonder that Halley's appearance was considered so significant in 11 B.C., for on this occasion the comet ventured close to Earth and became very impressive. The Chinese account is long and quite detailed regarding the comet's passage among the stars. It seems to have first been detected in the morning sky in late August at a considerable elongation from the Sun. The Chinese tell how the comet moved eastward at a rate of more than 6° per day, passing Castor and Pollux, Canis Minor, and Ursa Major. The tail seems to have extended to Polaris and beyond, possibly stretching more than 100° when the comet passed nearest us in early September. Thereafter, Halley was an evening object moving southeastward past Cor Caroli and Arcturus.

At the time, Halley was still approaching perihelion (which came on October 10.85 Universal Time) although rapidly receding from Earth. The net result was a slow fading from zero to about third magnitude as September drifted into October. The final sighting of the comet apparently occurred October 21st when Halley was in Scorpius north of Antares, deep in the twilight.

66 A.D.

In the minds of the fearful, the comet made an even more terrible omen when it returned one orbital revolution later. The Jewish historian Flavius Josephus wrote of several "prodigies" which announced the destruction of Jerusalem in 70 A.D. following the rebellion of Judea against Roman authority. Josephus notes, "Amongst the warnings, a comet, of the kind called Xiphias, because their tails appear to represent the blade of a sword, was seen above the city." The sword-like comet was, of course, Halley.

This was a winter apparition, with the comet coming to perihelion on January 25.96 in the constellation of Aquarius. Such being the case, it remained too faint for detection until after it had passed the Sun. Observation period: February 20th to April 10th.

The Chinese chronicles say that at discovery, the comet was near Beta Capricorni and had a tail about 12° long. It moved westward, passing the Milk Dipper of Sagittarius and the stars near Delta Scorpii. It grew brighter than first magnitude as it passed close to Earth late in March and, although not specifically mentioned, the tail must have been enormously long due to the comet's proximity.

66 A.D.

date	R.A.	Dec.	d	r	e	mag
Jan 31	21h 15m	−09.3°	1.44	0.60	12°	3.6
Feb 20	20 37	−12.7	0.96	0.79	48	2.3
Mar 2	20 08	−15.7	0.67	0.94	65	2.0
Mar 12	18 53	−22.2	0.38	1.09	93	1.3
Mar 22	14 21	−24.3	0.25	1.25	162	0.9
Apr 1	11 24	−07.8	0.48	1.40	139	2.7
Apr 21	10 27	+00.1	1.14	1.70	104	5.2

Oriental chronicles further relate that Halley traversed the constellation of Virgo before entering Crater, and that its tail pointed east. The comet then became nearly stationary in right ascension, moving only very slowly to the south until it dropped below naked-eye visibility in the second week of April.

141 A.D.

This return was particularly favorable for northern hemisphere observers, with the comet approaching close to Earth following perihelion (March 22.43). Such encounters result in the comet becoming very bright and the tail generally spanning many tens of degrees. Observation period: March 27th to late May.

The Chinese say that Halley first appeared in the eastern morning sky with a bluish-white tail up to 10° long pointing southwest. At first the comet's motion across the sky was hardly noticeable, but it became more evident as April progressed. When the Earth and comet passed one another about the third week of the month, Halley moved more than 90° in just a few nights, transferring itself from the morning to the evening sky.

Records show that on April 22nd, the comet appeared at dusk and passed both the Pleiades and Hyades in the northwest. By the next night, it was in western Gemini and probably outshone every other object in the nighttime heavens. Although no specific date is given, the chronicler makes reference to what must have been a gigantic tail.

The Chinese say in conclusion, "The comet was out of sight when it came into the midst of the stars in the head of Leo." The oriental astronomers were undoubtedly referring to the ecliptic longitude of this asterism, since the comet followed a path well to the south of these stars before becoming too faint. It disappeared in late May.

141 A.D.

date	R.A.	Dec.	d	r	e	mag
Mar 23	23h 41m	+06.7°	1.20	0.58	29°	3.3
Apr 2	23 39	+08.9	0.84	0.63	38	2.1
Apr 12	00 02	+16.3	0.45	0.73	41	0.3
Apr 17	00 54	+27.8	0.27	0.80	33	−0.5
Apr 22	04 53	+46.5	0.17	0.87	32	−1.2
Apr 27	08 52	+27.9	0.27	0.95	68	0.1
May 2	09 47	+16.4	0.44	1.02	79	1.4
May 12	10 19	+08.5	0.82	1.18	79	3.2
May 22	10 32	+05.3	1.19	1.33	74	4.5

218 A.D.

In the year 218 A.D., a large comet was recorded by both European and Chinese chroniclers. Dio Cassius described it as a very fearful star with a tail extending from the west toward the east. Observation period: April and May.

The written accounts in the *Hou Han Shu, Thung Chien Kang Mu*, and other Chinese astronomical records tell the following story: "During the period mid-April to mid-May a comet appeared in the morning in the east. After more than 20 days it appeared in the evening in the west. It trespassed against and passed western Gemini, the region of Castor and Pollux, the forefeet of Ursa Major, the northern stars of the 'Sickle' of Leo, and the 'Bowl' of Virgo. Its rays were pointed toward Hercules."

While this record gives only an approximate date when the comet was first seen, examination of the ephemeris can help pin down the date more closely. Before the second week of May, Halley was too low in the morning sky to be seen. Its greatest altitude before sunrise was reached about May 18th, and within the next two weeks it passed conjunction with the Sun and moved over into the evening sky. Thus the initial observations must date from within a few days of May 15th. This would agree with the statement that "after more than 20 days" the comet became an evening object.

218 A.D.

date	R.A.	Dec.	d	r	e	mag
May 3	02h 05m	+19.8°	1.31	0.67	30°	4.1
May 13	02 20	+25.0	0.93	0.59	35	2.8
May 23	03 36	+36.7	0.56	0.59	29	1.5
May 28	05 35	+43.3	0.44	0.62	20	0.7
June 2	08 17	+37.9	0.44	0.67	29	0.0
June 12	10 34	+16.9	0.72	0.80	51	1.6
June 22	11 11	+07.7	1.09	0.94	53	3.1
July 2	11 28	+03.3	1.45	1.10	49	4.2

Perihelion occurred on May 17.73, with the comet's closest approach to Earth taking place on May 30th (0.42 AU). About that time, Halley should have reached its maximum brightness of around zero magnitude.

295 A.D.

As the Moon waned in the first days of May, 295 A.D., the morning sky revealed the presence of a brilliant comet low in the east. The earliest observations placed it near Beta Andromedae and it must surely have been first magnitude. Unbeknownst to its observers, Comet Halley had completed yet another circuit of its orbit. Observation period: May.

Having already passed its perihelion (April 20.40), Halley was rapidly nearing Earth with closest approach coming during the second week of May (0.32 AU). As the two bodies swept by each other, the comet lay between the Sun and Earth. The effect on the comet's apparent motion against the background stars moved Halley eastward toward the Sun, passing well north of it, and then into the evening sky. In doing so, the comet traversed the constellations of Triangulum, Perseus, Auriga, Lynx, and Cancer. Rising dramatically out of the evening twilight, the comet continued on across the head of Leo and into northern Sextans. Here it remained until it faded from view.

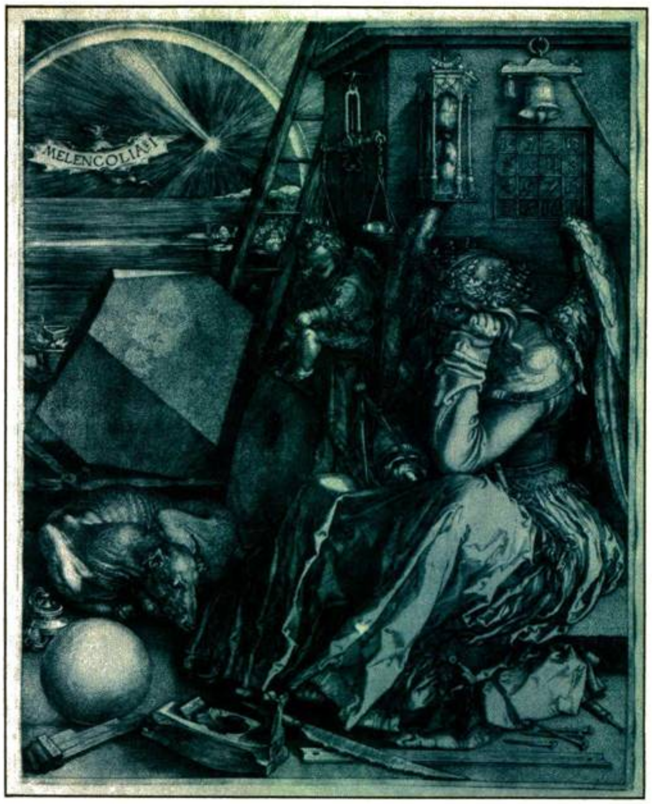
295 A.D.

date	R.A.	Dec.	d	r	e	mag
Apr 21	01h 00m	+17.1°	0.97	0.58	34°	2.8
May 1	01 37	+25.9	0.57	0.62	34	1.3
May 6	02 44	+35.2	0.41	0.67	25	0.1
May 11	05 30	+42.8	0.32	0.73	23	−0.4
May 16	08 24	+32.6	0.38	0.80	45	0.2
May 21	09 39	+21.0	0.52	0.87	59	1.3
May 31	10 31	+10.0	0.89	1.02	65	2.9
June 10	10 51	+05.4	1.26	1.18	61	4.2

374 A.D.

At its next encounter, Halley's Comet came exceedingly close to actually hitting us — the comet passed just 9 million miles outside Earth's orbit. Under the circumstances, Halley must have been an awesome sight, lying somewhat south of the celestial equator and visible all night long. It's therefore surprising — and disappointing — to find the descriptions in the oriental chronicles so vague and perfunctory. Observation period: March 4th through April.

Comet Halley was at perihelion on February 16.34, hidden in the twilight. Drawing away from the Sun, it was detected by the Chinese on March 4th in western Aquarius. According to the *Chin Shu*, "On April 2nd the comet was seen in Libra as a 'broom star.' It then passed the region of Iota Virginis, Spica, Corvus, Crater, and the region of Hydra southeast of the star Alphard." There is mention of a spectacular tail (perhaps more than 90° long), but nothing is said concerning extraordinary brightness.



Into the background of his 1514 engraving *Melancholia I*, Albrecht Durer set a brilliant (if unrealistic) comet. Courtesy Metropolitan Museum of Art.

374 A.D.

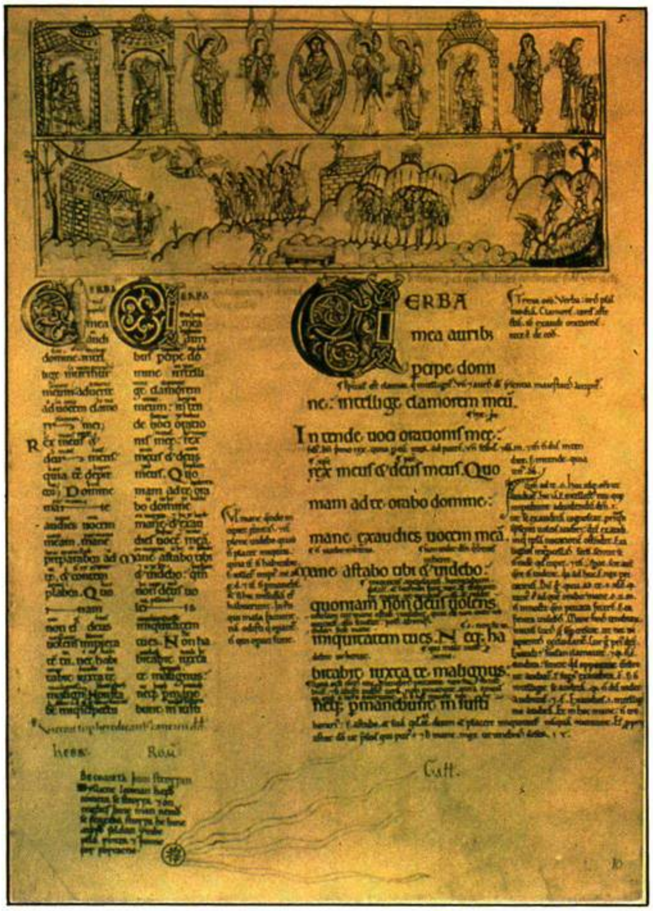
date	R.A.	Dec.	d	r	e	mag
Feb 22	22h 04m	−04.7°	1.31	0.59	25°	3.4
Mar 4	21 49	−06.0	1.02	0.67	39	2.1
Mar 14	21 34	−07.7	0.69	0.80	53	1.6
Mar 24	21 04	−11.9	0.34	0.95	70	0.6
Mar 29	20 05	−19.7	0.17	1.02	91	−0.6
Apr 3	14 00	−27.0	0.10	1.10	166	−1.6
Apr 8	11 12	−07.4	0.24	1.18	131	0.6
Apr 13	10 41	−02.6	0.42	1.26	118	2.0
Apr 23	10 25	+00.2	0.78	1.41	103	3.7

451 A.D.

As an omen, Halley gained new importance in 451 A.D. It was a time when all Europe was feeling the ravages of Attila the Hun: his conquests seemed unstoppable for all who challenged his army fell before him. Then, during the longest days of summer, there appeared a sign in the heavens. A great long-tailed star shown forth in the northern sky for nights on end. At the Battle of Chalons that year, one of the most terrible battles in history, Attila and his horde were defeated by the Roman

451 A.D.

date	R.A.	Dec.	d	r	e	mag
May 30	03h 30m	+23.5°	1.49	0.85	33°	5.5
June 9	03 48	+27.6	1.12	0.71	38	4.1
June 19	04 42	+35.2	0.74	0.61	37	2.4
June 29	08 02	+40.3	0.49	0.57	20	1.2
July 9	11 13	+18.3	0.66	0.62	36	1.4
July 19	12 03	+05.6	1.03	0.73	42	2.1
July 29	12 21	−00.1	1.40	0.87	38	3.4
Aug 8	12 30	−03.3	1.73	1.03	32	4.4
Aug 18	12 36	−05.6	2.02	1.18	25	5.2



Left: In 1145, Comet Halley was in the sky as the English monk Eadwine was copying a psalter; he placed a drawing and description of the comet at the bottom of the page. Courtesy of the Library of Congress, from the *Canterbury Psalter*. Right: Halley's return in 1301 probably inspired Giotto to portray it as the Christmas star in his fresco painted in Padua, Italy in 1303-1306. Courtesy Library of Congress.

general Aetius. Observation period: June 10th to August 16th.

At this return, the comet was probably detected first on June 10th emerging from the morning twilight. It was then still more than two weeks from closest approach to the Sun (June 28.25) and rapidly brightening.

In contrast to Halley's previous return, this apparition did not include any particularly close encounter to Earth. Still, the comet proved quite impressive in northern Europe where, toward the end of June, it remained above the horizon all night — its long curving tail slowly wheeling around the Pole Star.

On the night of discovery, Comet Halley lay close to the Pleiades and by around June 18th was within the pentagon of stars forming Auriga. A little more than a week later, Halley stood 10° north of Castor and Pollux, and shortly thereafter passed through conjunction with the Sun. During July it could be seen in the west after sunset, fading slowly as it crossed from Leo into Virgo. The last reported observation is that of August 16th near New Moon.

530 A.D.

Halley's appearance in September of 530 A.D. was not one of its more spectacular apparitions, but the descriptions left by European and Chinese chroniclers leave no doubt as to its identification. Observation period: August 29th to September 27th.

Halley passed the Earth on the inbound leg of its orbit on this occasion. At discovery, the comet was still nearly a month from perihelion (September 27.13) and increasing daily in brightness. The comet was also at its maximum northerly declination and its subsequent southerly motion limited its visibility. During the period of observation, Halley moved from Lynx to Libra.

530 A.D.

date	R.A.	Dec.	d	r	e	mag
Aug 19	06h 33m	+29.7°	0.69	1.00	70°	4.7
Aug 29	08 49	+37.5	0.35	0.85	54	2.4
Sep 3	11 52	+31.1	0.28	0.78	32	1.5
Sep 8	14 09	+12.1	0.36	0.71	30	1.6
Sep 18	15 30	−05.5	0.72	0.61	37	2.4
Sep 28	15 43	−11.2	1.11	0.58	31	3.1
Oct 8	15 40	−14.1	1.44	0.62	21	3.3

The Chinese reported a tail measuring 9° on August 29th, the longest for this apparition. On September 4th, the tail seemed no more than 2° long and no note of it was made after that time. The comet reportedly disappeared on September 27th following Full Moon.

607 A.D.

This return is notable for its strange and confused accounts in Chinese annals and for Halley's long period of visiblity. As in 374 A.D., the comet ventured quite close to Earth, but this time passed between our planet and the Sun. Observation period: February 28th (?) to June 7th.

The *Pei Shih* says a tailed star, extending across the heavens, was seen in Pegasus at the end of February. It disappeared from sight after 20 days, but reappeared in Gemini on March 13th. However, Halley was too near the Sun in the sky to be visible at the close of February, and it didn't reach Gemini until after April 20th. Perhaps there's an error in dates here.

607 A.D.

date	R.A.	Dec.	d	r	e	mag
Mar 26	23h 08m	+03.5°	0.95	0.63	37°	2.3
Apr 5	23 11	+05.3	0.57	0.73	46	0.9
Apr 15	00 11	+16.6	0.19	0.87	38	−1.0
Apr 20	06 16	+35.3	0.10	0.95	45	−2.2
Apr 25	09 28	+13.4	0.25	1.02	85	0.2
May 5	10 11	+05.5	0.63	1.18	89	2.7
May 15	10 24	+03.2	1.00	1.33	83	4.1
May 30	10 36	+01.5	1.54	1.56	72	5.6
June 14	10 46	+00.1	2.04	1.78	61	6.6

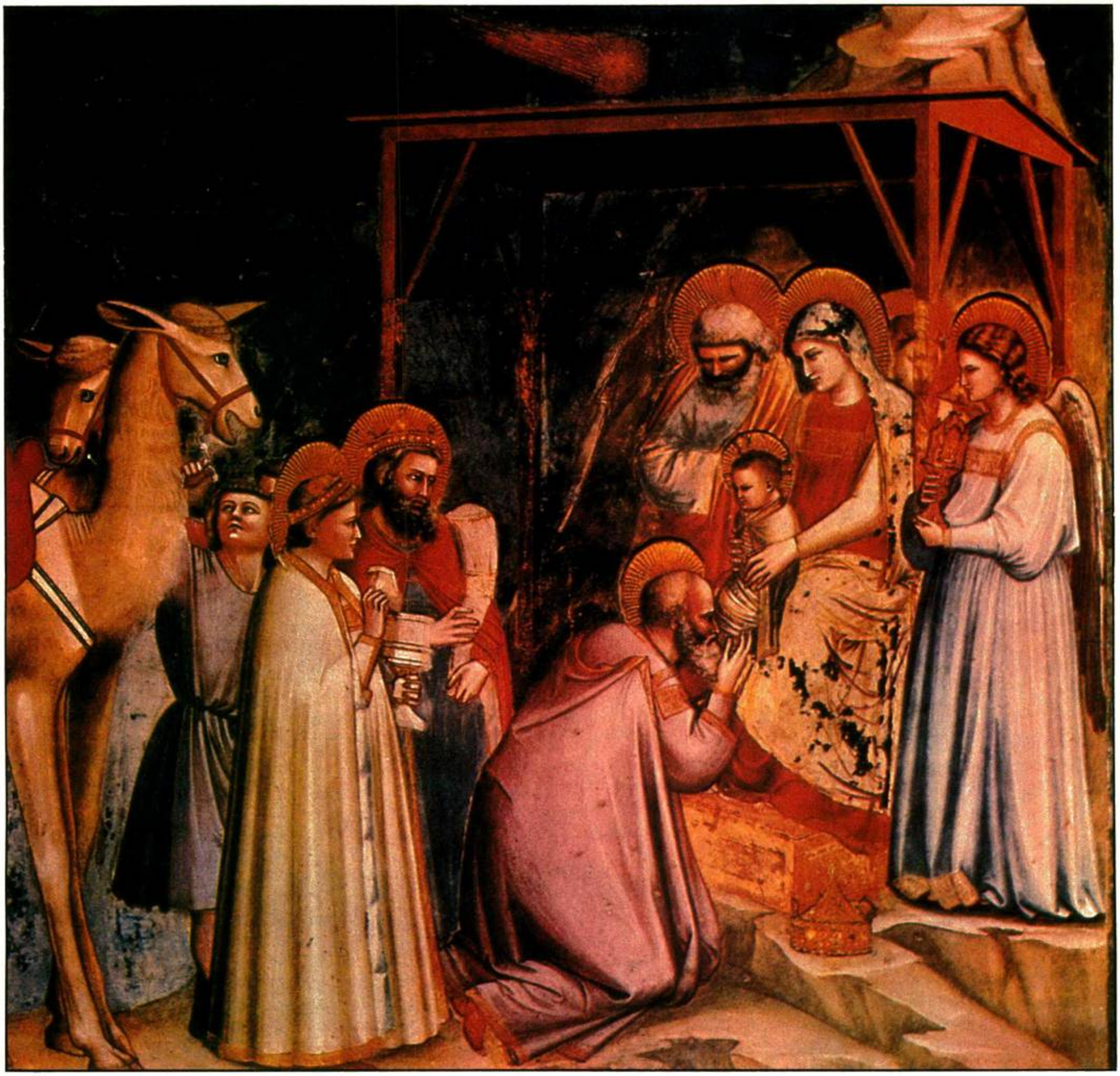
The *Wen Hsien Thung Khao* gives an account somewhat more identifiable with Halley. It indicates that a comet was found on April 4th before morning twilight in the longitude of Beta Andromedae. This text also indicates the comet "extended across the sky," perhaps implying a long tail was visible. Its motion eastward from Aries to Virgo is also possibly hinted at, but the closing sentence says the comet remained visible the rest of the year! Additionally, the comet is said to have "reappeared" in the south on October 21st. This latter object is almost surely a different comet, and not related to Halley. The *Pei Shih* allots the first comet "more than 100 days" of visibility, which seems more reasonable for Halley.

684 A.D.

Halley returned next during the late summer of 684 A.D., encountering Earth prior to perihelion passage. While the encounter circumstances wouldn't lead us to expect a first-class display, it was nonetheless noted almost universally and even depicted centuries later in the *Nuremberg Chronicles*. Observation period: August 31st to October 24th.

From Japanese records, Halley was first detected August 31st, when it lay not far from Castor and Pollux. The Moon was Full that night, which implies the comet was brighter than the third-magnitude figure calculated for that date. From the beginning of observations on this return, Halley shows a striking tail in spite of moonlight — with some reports regarding it as over 15° long. As the comet passed conjunction with the Sun toward the end of the first week of September, the tail stretched almost due north.

Entering the evening sky and approaching perihelion (October 2.77), Halley moved rapidly to the southeast and remained at low altitude following the end of evening twilight. Various Chinese chronicles imply Halley's visibility extended over some 49 days, or until October 24th. If true, the comet must have been unusually bright, for by that date it lay no more than



684 A.D.

date	R.A.	Dec.	d	r	e	mag
Aug 19	06h 16m	+28.0°	0.81	1.09	73°	5.4
Aug 29	07 28	+35.2	0.45	0.93	68	3.4
Sep 3	09 26	+39.7	0.30	0.86	54	2.1
Sep 8	12 52	+28.1	0.26	0.79	31	1.4
Sep 18	15 32	−01.9	0.55	0.66	39	2.2
Sep 28	15 58	−10.1	0.94	0.59	35	2.8
Oct 8	15 58	−13.7	1.30	0.59	26	3.4
Oct 18	15 51	−15.9	1.58	0.67	14	3.1
Oct 28	15 43	−17.6	1.78	0.79	3	3.6

6° from the Sun — normally impossible to detect.

The Chinese writings mention further sightings of a comet in early November, and again from December to January of 685, but these obviously refer to some other object.

760 A.D.

One revolution later, Halley graced the skies in May and June, 760 A.D. The comet passed somewhat farther from Earth on this occasion than it had 76 years earlier and consequently was less impressive. Observation period: May 16th to July 5th.

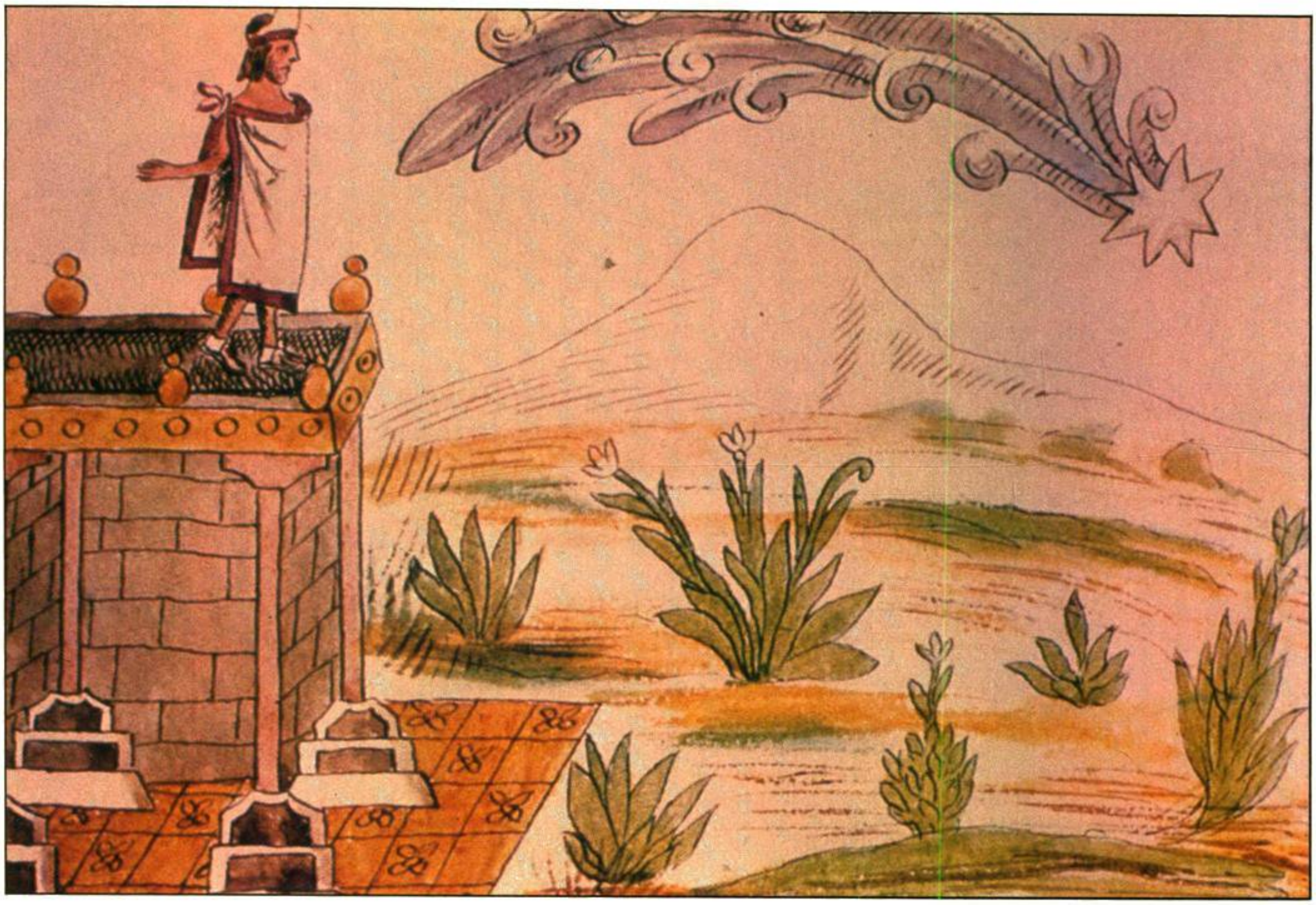
The Chinese records give the following account: "On May 16th a 'broom star' appeared at the 5th watch of the night in the east. It was white in color and measured 6° long. Starting in Aries it moved rapidly toward the northeast, passing the Pleiades, Hyades, the head of Orion, western Gemini, Cancer, the head of Hydra, and the 'Sickle' of Leo, before it reached a position within the 'Bowl' of Virgo. After more than 50 days it went out of sight."

As was often the case, Halley appeared in the wake of a waning Moon. Likely of second magnitude, it must have initially lain quite near the star Hamal (Alpha Arietis) in the morning sky.

760 A.D.

date	R.A.	Dec.	d	r	e	mag
May 6	02h 07m	+20.3°	1.32	0.66	30°	4.1
May 16	02 20	+25.1	0.94	0.59	35	2.8
May 26	03 35	+35.9	0.55	0.59	29	1.5
May 31	05 31	+41.9	0.43	0.62	19	0.7
June 5	08 12	+36.4	0.43	0.67	28	0.2
June 15	10 34	+15.1	0.70	0.80	51	1.6
June 25	11 11	+06.1	1.07	0.94	54	3.1
July 5	11 28	+01.8	1.43	1.10	50	4.2
July 15	11 39	−00.9	1.77	1.25	44	5.1

At discovery, Halley was only four days from perihelion (May 20.67) and when at its brightest was located to the north of



Gemini. It was then visible low over the northwestern horizon after evening twilight ended. The comet's greatest eastern elongation came during the second half of June; thereafter, Halley slipped slowly back into the evening twilight late in July.

837 A.D.

The most outstanding return during the first millennium A.D., this passage included Halley's closest known approach to Earth — a scant 3 to 4 million miles — on April 9th. Based on descriptions worldwide, no other apparition has rivaled this one in grandeur. Observation period: March 22nd to April 28th.

Chinese records of this return are so extensive that no single account can be presented here. The following is excerpted from the *Chiu Thang Shu* chronicle. "On March 22nd, a 'broom star' appeared in the first degree of Pegasus [near Enif]. It measured over 10° and pointed westward. On April 6th its length exceeded 15° and it was seen moving westwards. On April 7th its length was over 30° and its width more than 5°. On April 9th, it was seen in Sagittarius with its length measuring more than 75°. Its tail then branched off into two streams, one pointing towards Libra and the other enveloping Delta Scorpii. On the night of April 11th, it measured 90°, but was no longer branched and pointed toward the north. On April 13th the comet measured 120° and moved toward the northwest. By the 28th of April the comet measured 5° . . . and was situated in the 10th degree of the middle stars of Hydra."

837 A.D.

date	R.A.	Dec.	d	r	e	mag
Mar 6	22h 28m	−02.2°	1.25	0.60	28°	3.2
Mar 16	22 16	−03.3	0.93	0.68	41	1.7
Mar 26	22 07	−04.7	0.58	0.80	53	1.2
Apr 5	21 50	−09.5	0.21	0.95	68	−0.4
Apr 10	19 05	−44.1	0.04	1.03	115	−3.8
Apr 15	10 41	−06.5	0.17	1.10	119	−0.4
Apr 25	10 24	−00.5	0.54	1.26	104	2.6
May 5	10 24	+00.3	0.91	1.41	94	4.1

Halley's spectacle at this return probably outdid all other comets of recorded history. When Halley was nearest, it lay just outside Earth's orbit in the "midnight" portion of the heavens, far removed from twilight. Like one express train passing another, Halley hurtled by us at enormous velocity, crossing 60° of sky in 24 hours. Its brightness must have been astonishing, equaling Venus at maximum light, while the tail — which pointed from south to north when the comet was at its nearest — spanned most of the vault of the heavens.

912 A.D.

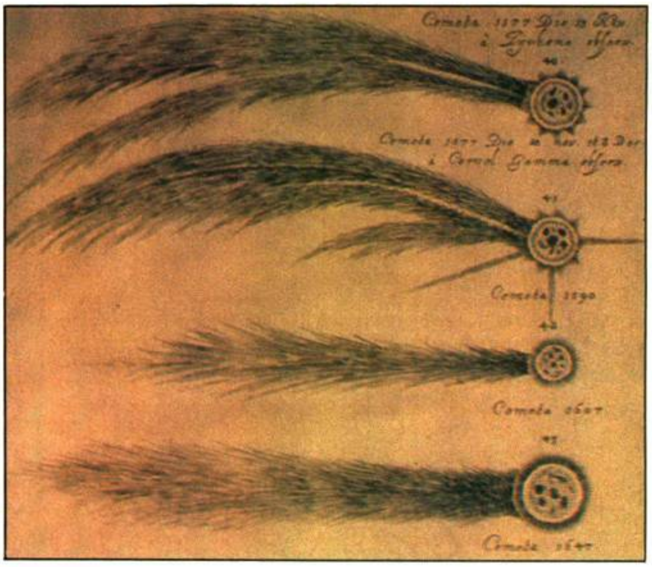
After the amazing apparition of 837 A.D., those immediately following are rather anticlimatic. At the return of 912 A.D., Halley passed nearly a dozen times farther from Earth than it had 75 years before. In consequence, Halley was little noted and perhaps for the first time Chinese astronomers may have missed it altogether. Observation period: July 19th to July 28th.

912 A.D.

date	R.A.	Dec.	d	r	e	mag
June 29	04h 44m	+31.8°	0.95	0.72	43°	3.8
July 9	06 26	+40.0	0.59	0.62	34	2.0
July 14	08 28	+39.9	0.49	0.59	23	1.4
July 19	10 34	+29.3	0.51	0.58	23	1.4
July 29	12 21	+08.2	0.81	0.62	38	2.1
Aug 8	12 49	−00.5	1.19	0.73	38	2.5
Aug 18	12 59	−04.8	1.55	0.87	32	3.6

Chinese chronicles record a comet in Leo during mid-May, 912, but at the time Halley wasn't brighter than eighth magnitude and lay in a different part of the sky. However, the Japanese did see Halley during the month of July according to the *Dainihonshi* chronicle. It says that on July 19th a comet appeared in the northwestern evening sky. There are further observations from the 25th and 28th that refer to its moving west.

Halley was nearest the Sun (July 18.68) one day before it was first seen, and would have been an evening object low in the northwest after evening twilight faded. During the following



Left: The Aztec ruler Montezuma watches a comet (not Halley's) whose arrival "predicted" his defeat at the hands of Hernando Cortes. From *Los Tiacuilos de Fray Diego Duran*, Carton y Papel de Mexico. Right: In his 1668 book *Cometographia*, Johannes Hevelius depicted the 1607 return of Halley (third from top) in a plate showing different types of comets. Courtesy Library of Congress.

days, its declination quickly decreased as the comet moved toward the southeast, crossing Leo and entering Virgo. As a result, it would have remained low in the evening sky, slowly edging southward and reaching the west point on the horizon about the time it was last seen.

989 A.D.

To finish the first millennium A.D., Comet Halley completed one more circuit around the Sun. Like its other 10th-century return, this one was not particularly conspicuous. With the comet at perihelion on September 5.69 and the Earth encountering the comet before it reached its least distance from the Sun, Halley likely never became brighter than first or second magnitude. Observation period: August 13th to September 12th.

In the year 989, Chinese and several Anglo-Saxon writers recorded the passage of a comet across the heavens during late summer. The Chinese first observed the comet on August 13th near the border between Auriga and Gemini. They write that it remained visible in the northeastern sky before dawn for 10 days and then moved into the evening. The comet is described as bluish-white in color; its tail seems to have increased in length as days passed, though no actual size is given.

989 A.D.

date	R.A.	Dec.	d	r	e	mag
Aug 2	05h 58m	+30.8°	0.89	0.93	58°	4.9
Aug 12	07 30	+37.5	0.54	0.79	51	3.0
Aug 17	09 25	+38.4	0.41	0.72	37	2.0
Aug 22	11 53	+27.6	0.40	0.67	24	1.5
Sep 1	14 07	+02.5	0.68	0.59	35	2.1
Sep 11	14 36	−06.8	1.07	0.59	33	2.8
Sep 21	14 40	−10.9	1.43	0.67	25	2.8
Oct 1	14 39	−13.4	1.71	0.80	15	3.5

As an evening object, Halley drifted southeastward from Canes Venatici through Coma Berenices into Virgo as September progressed. Finally, after reaching the region near Kappa Virginis, the comet vanished from sight.

1066 A.D.

This was perhaps Halley's most famous apparition, since it preceded the Norman Conquest by only a few months. It was on this occasion that the comet was recorded by the makers of the Bayeux Tapestry. Observation period: April 1st to June 7th.

Halley was in conjunction with the Sun early in March 1066. During the second half of the month, it moved out into the morning sky, but then the light of the waning Moon hid it. Not until April 2nd, when the comet was already two weeks past perihelion (March 20.93), was it first reported by the Chinese. Probably at first or second magnitude, the comet lay near Gamma Piscium and oriental records indicate it had a tail roughly 10° to 15° long pointing southwest.

Initially, Halley's eastward motion against the stars was slow, but this gradually increased and the comet again became lost in twilight until the evening of April 24th. This was also the date of the comet's closest approach to Earth, the two missing each other by a mere 10 million miles. This proximity resulted in the comet becoming very brilliant in the western sky. Undoubtedly, the head of the comet was at least magnitude −2 and some reports compare it to Venus (−4). Chinese records mention that it appeared without a tail against the bright twilight sky; Korean records say "a star like the Moon rose in the northwestern sky."

1066 A.D.

date	R.A.	Dec.	d	r	e	mag
Mar 11	23h 36m	+04.3°	1.54	0.62	14°	4.1
Mar 31	23 17	+04.3	0.93	0.62	37	2.1
Apr 10	23 25	+05.8	0.55	0.72	44	0.7
Apr 20	00 54	+16.2	0.18	0.86	30	−1.2
Apr 22	02 26	+23.4	0.12	0.89	11	−1.9
Apr 24	05 24	+26.8	0.11	0.92	31	−2.1
Apr 26	07 46	+19.3	0.14	0.95	62	−1.3
Apr 30	09 21	+09.5	0.28	1.01	82	0.4
May 10	10 09	+03.6	0.65	1.17	86	2.7
May 30	10 33	+00.7	1.39	1.48	74	5.1

To judge by these accounts, the comet's tail must have reached prodigious lengths. The tail traversed the polar regions as the comet passed through its second conjunction with the Sun and may have bridged the greater part of the heavens. Over the next few days as Halley traversed Gemini, its tail swung around to the east and extended to Coma Berenices, or upwards of 70°.

This splendor didn't last long, however, for the comet was receding from both the Earth and Sun. By May 5th, Halley was likely no brighter than second magnitude and records make little mention of the tail. The comet was followed until the 7th of June, when it was almost stationary in Sextans, south of first-magnitude Regulus.

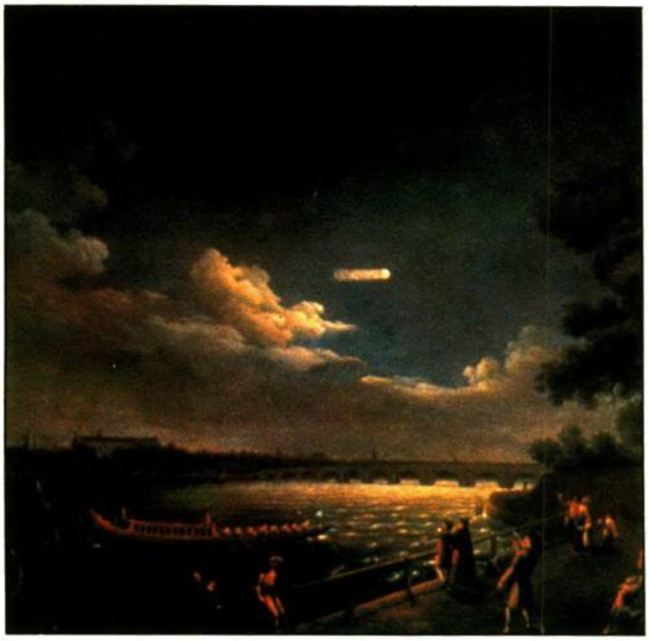
1145 A.D.

The perihelion date (April 18.56) at this apparition came almost exactly one month later than that of 1066. Thus, the comet's path across the sky was similar to that one revolution earlier. Observation period: April 26th to July 9th.

April 26th is the date given by the Chinese chronicles for the comet's discovery. It was again situated in the morning sky, in Pisces, and probably of first magnitude. Discovery once again occurred shortly after moonlight ceased to hide the object. Already rapidly closing in on Earth, the comet appeared moving briskly to the northeast.

In the first few days of May, Halley lay in Aries and was roughly zero magnitude, but was too low in the sky to see until late twilight. By May 9th, when the comet was little more than 15° from the Sun, the Japanese reported a tail 20 "feet" long, which may correspond to about 30° or so. During the second week of the month, Halley was hidden in twilight while it traversed Triangulum and Perseus, then entered Auriga in the evening sky. It was noted on May 16th, when it still must have been at least zero magnitude with a tail again 20 "feet" long. The comet quickly crossed Gemini (passing between Castor and Pollux), Cancer, and Leo to become an imposing object in the western sky.

Halley's splendor passed by month's end and it lost all trace of its tail by early June, for on the 4th Chinese records say, "it was transformed into a 'guest star' and its color was bluish-white." This could possibly be interpreted as some sort of outburst in the comet's brightness because it remained visible to the naked eye much longer than normal. Eventually, its motion came to rest almost midway between Regulus and Lambda Hydrae; it was last reported seen on July 9, 1145.



1759: The return which attached Edmond Halley's name to the comet. Painting by Samuel Scott, Courtesy Library of Congress.

1145 A.D.

date	R.A.	Dec.	d	r	e	mag
Apr 15	00h 40m	+13.1°	1.19	0.58	29°	3.2
Apr 30	01 06	+19.8	0.61	0.63	36	1.2
May 10	03 59	+35.5	0.29	0.74	15	−0.6
May 15	07 29	+30.8	0.29	0.81	39	−0.3
May 20	09 16	+18.2	0.42	0.88	60	0.8
May 30	10 20	+07.2	0.79	1.04	69	2.7
June 15	10 51	+01.5	1.38	1.29	63	4.7
June 30	11 05	−01.1	1.89	1.52	53	5.9

1222 A.D.

This return of Halley's Comet engenders a certain amount of mystery, since some observations imply the comet was unexpectedly bright — but the data are too vague for certainty. An autumnal apparition, the comet was initially a morning object and probably would have been detected around August 25th had not the Moon been Full two nights earlier. As Halley grew brighter the Moon drew nearer to its position, effectively preventing discovery. Observation period: September 3rd to October 8th.

The first sighting came from Korea on September 3rd when the comet was reported near Lambda Ursae Majoris. On the 8th, it was seen near the northwestern horizon with a tail 20 "feet" (perhaps 30°) long. A most unusual observation was made on September 9th: according to Korean sources, "It was seen in the day[time]." If correct, this implies a magnitude of −2 or −3 — much brighter than would be anticipated for that date.

The Chinese first noted the comet in the evening sky after sundown on September 10th. It was in Bootes about half a dozen degrees southwest of Arcturus. Depending on how we interpret the wording, the comet may have been quite spectacular. The *Sung Shih* chronicle notes, "Its rays measured 3 feet [or possibly 30 feet] and its structure looked like Jupiter." Are they saying the comet was as brilliant as Jupiter?

During September, with Halley still approaching perihelion (September 28.83), the comet's elongation from the Sun never became very great. Maximum separation, some 37°, was reached on the 20th. The comet's motion steadily carried it to the south, placing it less and less favorably for observation. The final sighting occurred on October 8th, with the comet in Libra.

1222 A.D.

date	R.A.	Dec.	d	r	e	mag
Aug 21	06h 33m	+31.6°	0.74	1.00	67°	4.8
Aug 31	08 36	+39.3	0.40	0.84	55	2.7
Sep 10	13 44	+17.6	0.36	0.71	29	1.6
Sep 20	15 18	−03.7	0.70	0.61	37	2.3
Sep 30	15 35	−10.8	1.09	0.57	32	3.0
Oct 10	15 33	−14.2	1.43	0.63	22	3.0

1301 A.D.

Nearly all historians of this period record the appearance of a great comet in the year 1301, with observations coming from as far afield as Iceland and Japan. Observation period: September 15th to October 31st.

Of particular interest is this return's association with the Arena Chapel frescoes painted by Giotto di Bondone in Padua, Italy. In the nativity scene depicted there, a comet represents the Star of Bethlehem. It is almost certainly based on Halley, for this was the only really bright comet to appear during that period.

1301 A.D.

date	R.A.	Dec.	d	r	e	mag
Sep 10	06h 43m	+32.0°	0.57	1.10	84°	4.7
Sep 20	09 25	+48.7	0.23	0.95	70	2.0
Sep 25	14 26	+32.9	0.19	0.87	44	1.2
Sep 30	16 13	+06.5	0.32	0.80	44	1.9
Oct 15	16 59	−11.6	0.89	0.62	38	2.9
Oct 30	16 50	−16.3	1.39	0.58	21	3.6

The comet was discovered in the morning sky just before Full Moon. An object of perhaps second or third magnitude, its celestial position lay in Lynx, to the north of Castor and Pollux. In spite of moonlight, the records speak of a tail possibly 8° to 15° in length.

The comet's motion carried it through the feet of Ursa Major, Canes Venatici, Bootes, and into Serpens before the close of September. Thereafter, Halley's motion against the stars slowed and it was last seen on October 31st in Ophiuchus with a 1 "foot" tail.

1378 A.D.

Very little mention of this apparition appears in the literature. The comet's discovery also seems surprisingly slow in coming, occurring when the comet was nearly at its closet to Earth. Theoretically, it should have been conspicuous for at least the previous week with little or no interference from moonlight. Observation period: September 26th to November 10th.

At discovery on September 26th, Halley was a little east of the pentagon of Auriga and was likely at third magnitude. Its position placed it not far from the zenith for most northern hemisphere observers at dawn. The comet moved rapidly to the northeast and passed within 10° of the north celestial pole on the night of October 2nd. On the following night it was nearest Earth, the two bodies being about 11 million miles apart. The Chinese speak of a tail 15° or so long about this time, but this must be considered a minimum since the Moon was almost Full and drowning out all but the brightest portions.

1378 A.D.

date	R.A.	Dec.	d	r	e	mag
Sep 20	06h 21m	+31.3°	0.53	1.20	98°	5.0
Sep 30	07 10	+59.2	0.18	1.04	99	1.9
Oct 2	10 00	+77.8	0.13	1.01	92	1.1
Oct 3	15 03	+74.6	0.12	0.99	86	0.8
Oct 5	17 16	+42.8	0.13	0.96	72	0.9
Oct 10	17 52	+05.6	0.28	0.89	60	2.2
Oct 25	17 57	−11.8	0.83	0.68	43	3.2
Nov 10	17 41	−16.4	1.34	0.58	23	3.5

Following its encounter with Earth, the comet moved rapidly southward in the evening sky on its way to perihelion (November 10.69). Down through Draco, Hercules, and Ophiuchus the comet sped, but the chronicles give little insight to its appearance. Final note of it is taken on November 10th when the comet lay not far from Xi Serpentis.

1456 A.D.

This return was one of the most *favorable for observing* Halley during the perihelion phase of its orbit. Contemporary writers regarded the comet as "terrible and of extraordinary magnitude [size]." Observation period: May 27th to July 8th.

The Chinese saw it first on May 27th when it was in Aries with a waning Moon present. The comet's magnitude was probably near +3 and a tail several degrees long was reported. By June 7th, just two days before perihelion (June 9.63), the tail had lengthened to at least 15° and the comet must have been first or second magnitude.

1456 A.D.

date	R.A.	Dec.	d	r	e	mag
May 16	02h 40m	+21.8°	1.55	0.79	27°	5.2
May 31	03 00	+27.7	1.00	0.62	36	3.2
June 10	04 10	+36.7	0.62	0.58	31	1.8
June 15	05 53	+41.4	0.48	0.59	21	0.6
June 20	08 22	+36.2	0.45	0.62	22	0.5
June 30	10 52	+13.8	0.70	0.73	46	1.3
July 15	11 42	+01.2	1.26	0.94	48	3.4

At closest approach to Earth, Halley was almost midway along a line joining our planet with the Sun. It was then at its most brilliant, low in the western sky after sunset. While most reports indicate a tail on the order of 10° to 25° long, some show it may have briefly reached a maximum of 60°.

As the comet moved further eastward and approached Leo, its motion slowed. Chinese writings note that on June 28th, the tail had decreased to about 10° or 15°, but the comet's head must still have been first magnitude. Moonlight finally seems to have obscured the comet toward the end of the first week of July — when the Chinese could still perceive a short tail, however.

1531 A.D.

At the end of July 1531, for the first time European annals recover the comet ahead of the Chinese. Halley must have been brighter than indicated in our ephemeris, for its discovery took place with the Moon just past Full. Observation period: August 5th to September 8th.

Halley's Comet was just east of Auriga and well up in the northeastern morning sky at dawn when it was first seen; on August 5th, the Chinese noted several degrees of tail despite the moonlight. When the comet was very low over the horizon at dawn on August 18th, Korean astronomers described the comet as whitish in color with a tail up to 15° long. This same figure is recorded in a European chronicle for August 13, with the comet in Leo Minor almost due north of the Sun.

1531 A.D.

date	R.A.	Dec.	d	r	e	mag
July 16	05h 08m	+28.0°	1.35	1.03	49°	6.3
July 31	06 07	+35.0	0.80	0.81	51	4.0
Aug 10	08 38	+40.4	0.49	0.68	36	2.1
Aug 20	12 35	+17.7	0.52	0.60	28	1.6
Aug 30	13 48	−00.4	0.87	0.59	36	2.7
Sep 14	14 07	−09.5	1.43	0.71	27	2.7

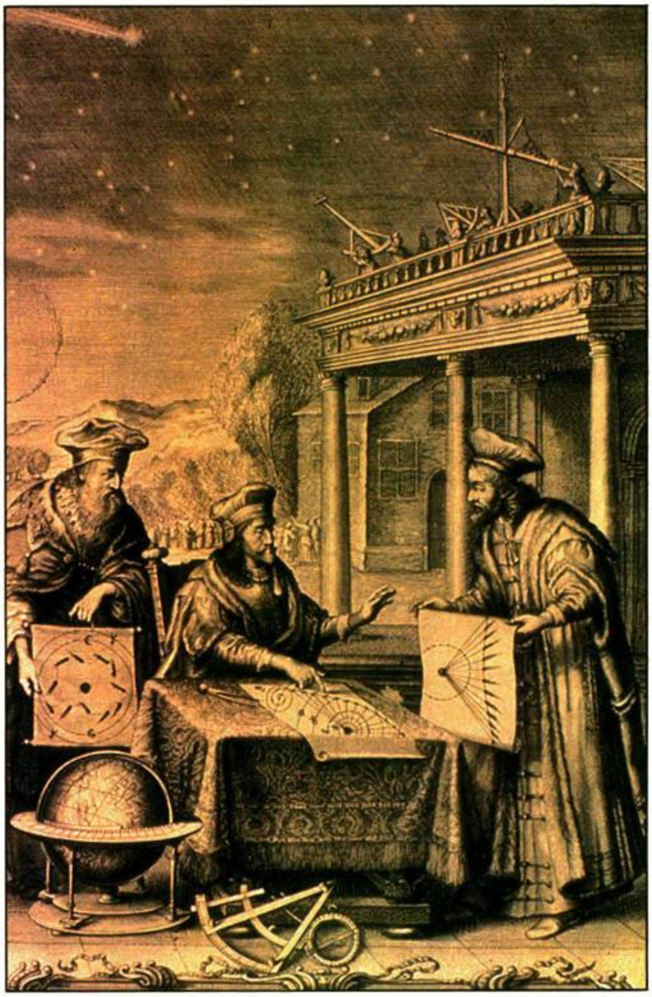
Traveling eastward, Halley entered the evening sky in mid-August, about a week before reaching perihelion (August 26.24). It must have been first magnitude about this time with an impressive northward-pointing tail.

Somewhat surprisingly, no one seems to have bothered recording much about the comet's appearance once it became an evening object. (This may result from the comet's southerly declination in late August and September.) But whatever the cause, Halley was followed only until September 8, when it was likely a second-magnitude object in eastern Virgo.

1607 A.D.

By the time the comet returned again, modern astronomy had finally come on the scene. The illustrious astronomer Johannes Kepler observed Halley's Comet from Prague and, beginning here, European records provide actual (albeit approximate) magnitudes for the comet. Observation period: September 21st to October 26th.

Halley was seen first in China on the 21st of September, high in the morning sky to the north of Castor and Pollux. Six days later, European observers estimated the comet at second magnitude. Comet Halley moved rapidly to the east and, by the close of September while in Ursa Major, was at first magnitude, had a 15°-long tail, and was above the horizon most of the night.



A 17th century view of comet orbits: the astronomer at left argues they lie near Earth, while the figure on the right claims they move in straight lines. Johannes Hevelius' own view, center, was that comets move in parabolas. From *Cometographia*, courtesy Library of Congress.

During the first week of October, the comet descended through Bootes and Serpens, a second-magnitude object with a long bright tail in spite of moonlight. By mid-month, now reported as about magnitude 2.3, Halley was rapidly approaching perihelion (October 27.54) and its elongation from the Sun was dwindling. The final observation was made on October 26th, with the comet in southern Ophiuchus.

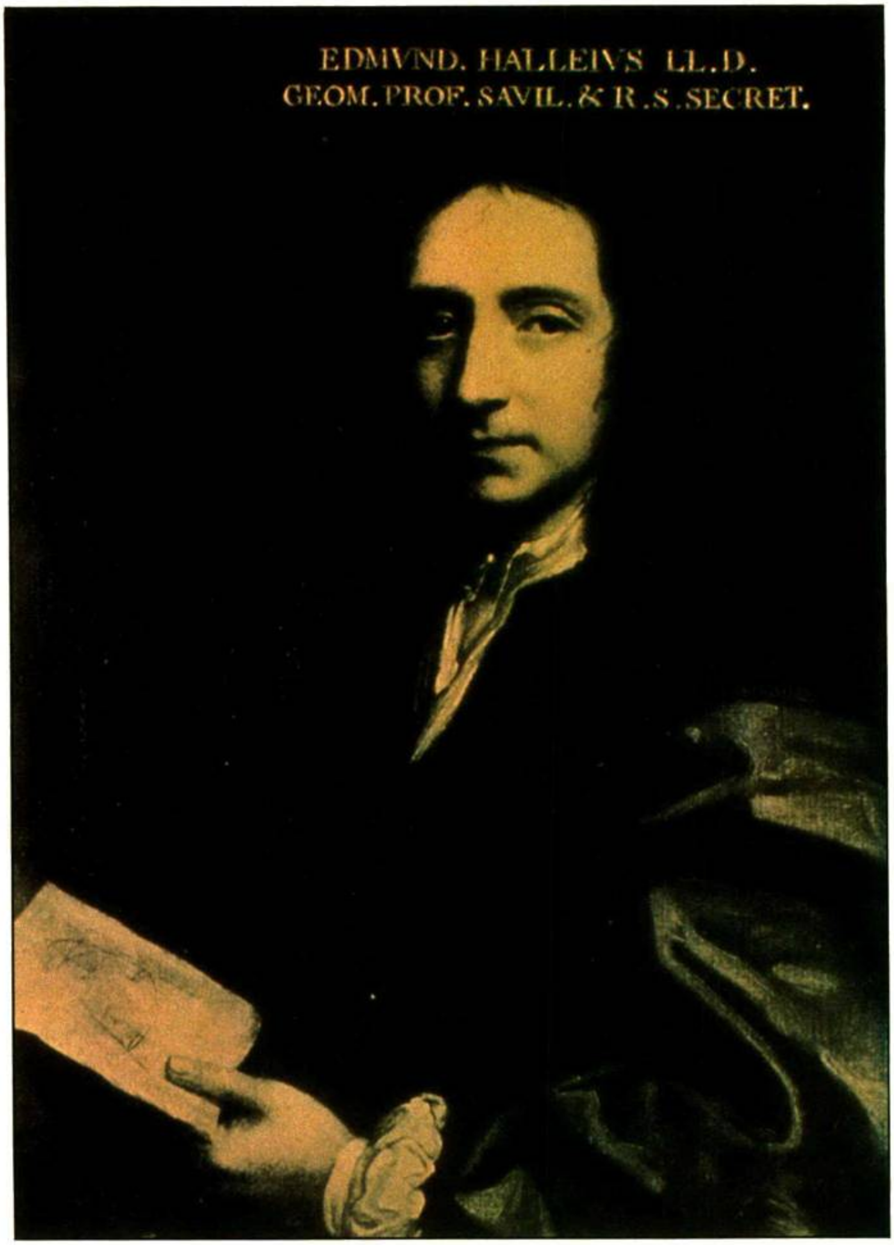
1607 A.D.

date	R.A.	Dec.	d	r	e	mag
Sep 10	06h 25m	+30.8°	0.81	1.13	76°	5.6
Sep 20	07 31	+39.6	0.45	0.98	74	3.7
Sep 25	09 29	+46.6	0.30	0.90	62	2.4
Sep 30	13 20	+35.5	0.25	0.83	41	1.6
Oct 5	15 19	+11.6	0.35	0.76	39	1.9
Oct 10	16 01	−00.5	0.52	0.70	42	2.4
Oct 30	16 25	−14.5	1.26	0.59	27	3.5

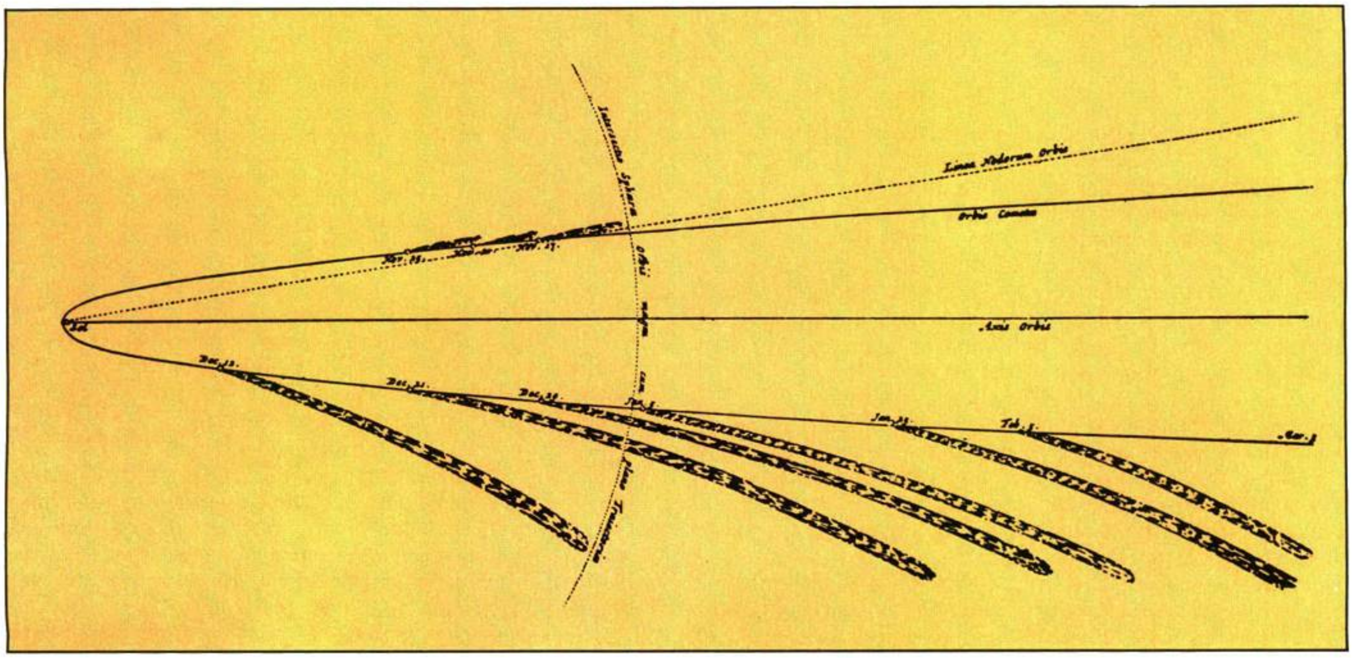
1682 A.D.

It was following this apparition that Edmond Halley made the epochal calculations which linked this return with those of 1607 and 1531. Interestingly, this was not a particularly spectacular appearance for the comet — in fact, it was apparently very much inferior to another comet observed only two years earlier! Observation period: August 26th to September 22nd.

Detected first in moonlight by La Hire and Picard in France


EDMVND. HALLEIVS LL.D.
GEOM. PROF. SAVIL. & R.S. SECRET.

Edmond Halley was already a noted man of science at age 30 when this portrait was painted. Below are pages from his notebook containing observations of the comet of 1682 which now bears his name; at bottom is his orbit for the bright comet of 1680, pubished in Newton's *Principia*. Courtesy Library of Congress.


Intersectio Sphaerae Orbis magni cum plano Trajectoriae
Linea Nodorum Orbis
Orbis Cometae
Sol
Axis Orbis
Dec. 12.
Dec. 21.
Dec. 29.
Jan. 25.
Feb. 5.
Mar. 5

on August 26th in the constellation of Lynx, the comet was visible before dawn in the northeastern sky as an object of second magnitude. As days passed the comet traversed Leo Minor, trailing a tail which attained a 30° length on August 28th.

Closest approach to Earth occurred on September 1st, when the comet was 39 million miles from us. About this time, it was visible both in the evening and morning skies by virtue of its northerly declination. Early in September, the comet became an evening object as it passed between Ursa Major and Leo to enter Coma Berenices.

1682 A.D.

date	R.A.	Dec.	d	r	e	mag
Aug 21	06h 58m	+38.6°	0.65	0.80	52°	3.5
Aug 26	08 24	+41.5	0.50	0.73	43	2.5
Aug 31	10 42	+36.6	0.42	0.67	29	1.7
Sep 5	12 39	+21.4	0.47	0.63	27	1.6
Sep 10	13 39	+08.2	0.61	0.59	33	1.9
Sep 20	14 21	−04.9	0.99	0.59	35	2.9
Sep 30	14 29	−10.4	1.36	0.67	28	2.9

Moving quickly to the southeast, the comet passed from Coma into Virgo on the night between September 7th and 8th. The Moon, New on the 2nd of the month, was now waxing and hindered observation of the comet's tail. A mere 2° length was detectable on the 9th, although the comet was still of second magnitude.

The comet reached perihelion on September 15.28 and observations continued until September 22nd. The comet was then not far east of Iota Virginis and perhaps close to third magnitude.

1759 A.D.

This was one of the finest apparitions in modern times, with the comet attaining spectacular dimensions; it was also the comet's first predicted return. Although Charles Messier was the first astronomer of note to spot the comet (January 21, 1759), it was detected earlier by a farmer-amateur astronomer named Johann Palitzsch in Germany on Christmas night, 1758. Observation period: December 25, 1758 to June 5, 1759.

When observed by Messier, the comet was a sixth or seventh-magnitude object in western Pisces in the evening sky. Messier's superiors stifled any public announcement of the recovery until after perihelion (March 13.06), so no one else saw the comet in January or February.

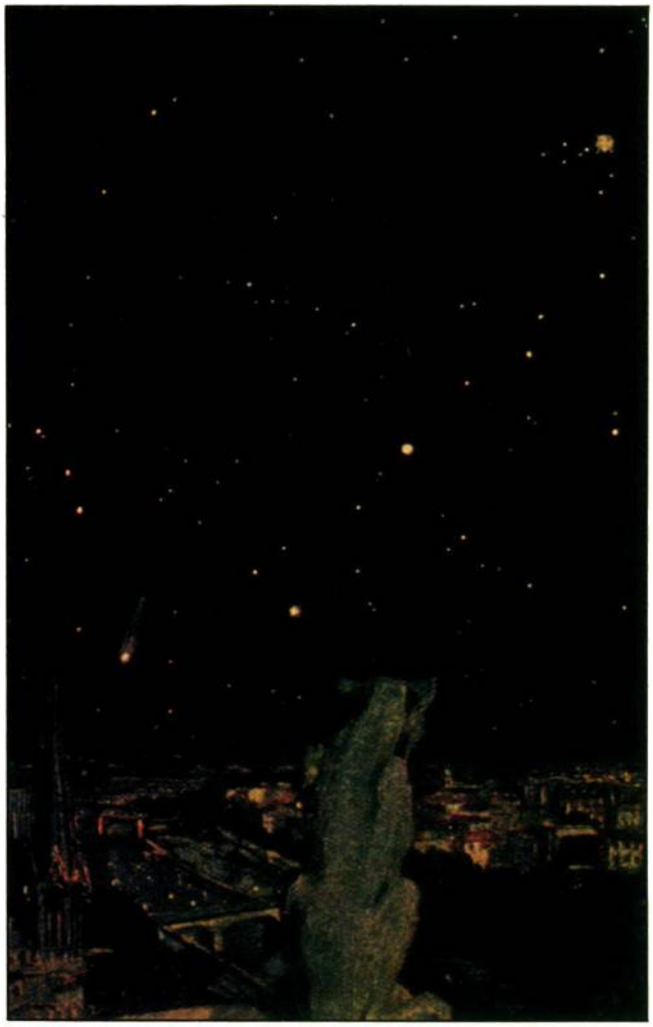
Messier was also first to see Halley emerge from the morning twilight on April 1st. He reported a 25° tail and a nucleus comparable to a first or zero-magnitude star. By then, the comet — an extraordinary object traveling rapidly southwestward in Aquarius — was being observed throughout the world.

As the comet approached Earth (least separation: 11 million miles on April 26th), its southerly declination briefly carried it beyond the view of European astronomers. Halley's reappearance above the southern horizon in the first days of May was all the more spectacular. The comet's head was at least first magnitude and the tail spanned no less than 47°.

1759 A.D.

date	R.A.	Dec.	d	r	e	mag
Jan 15	23h 52m	+03.5°	1.40	1.28	62°	7.4
Feb 15	23 04	+00.7	1.67	0.81	20	5.6
Mar 15	22 23	−03.0	1.39	0.59	21	3.7
Mar 31	22 03	−07.0	0.93	0.70	42	1.7
Apr 15	21 45	−16.8	0.42	0.91	65	0.9
Apr 23	20 47	−45.5	0.17	1.03	93	−0.6
Apr 25	18 56	−65.6	0.13	1.06	111	−1.1
Apr 27	13 10	−64.6	0.13	1.09	128	−1.0
May 1	10 55	−30.6	0.22	1.15	126	0.3
May 11	10 26	−10.8	0.56	1.31	109	2.7
May 30	10 26	−05.0	1.24	1.60	89	5.1

Now an evening object in Hydra, Comet Halley moved almost directly northward, fading slowly as it went. By mid-May, the comet was down to third magnitude although its tail still could be traced 19°. The final sighting was reported on June 5th from France, when the comet was fifth magnitude and low in the western sky.



1910: Halley's Comet over Paris. Courtesy Library of Congress, from M. Proctor's *Children's Book of the Heavens*, 1925.

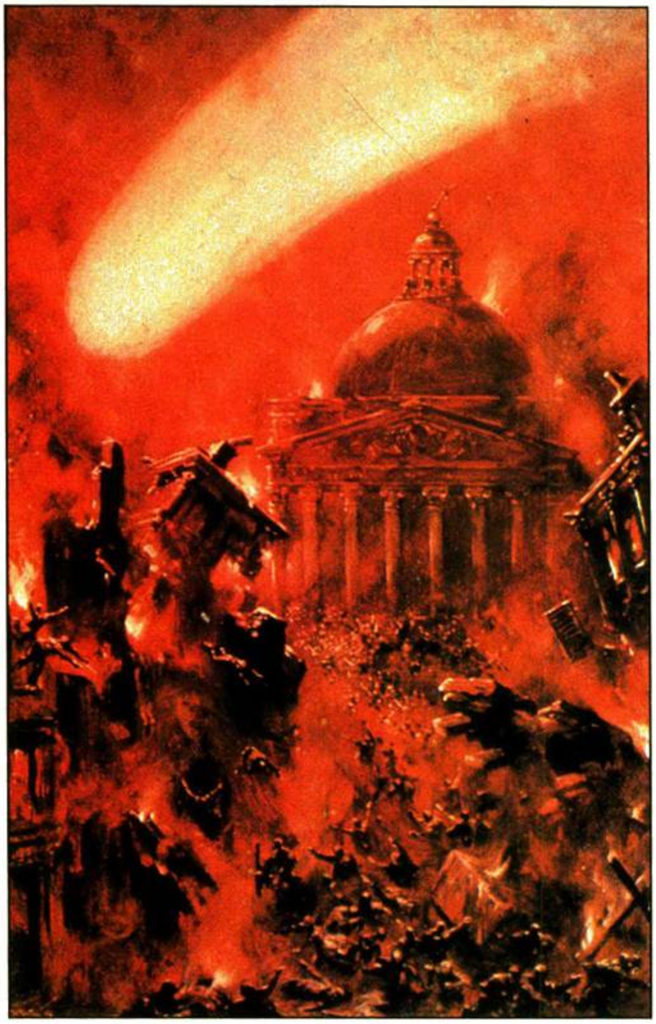
1835 A.D.

This autumnal apparition highly favored northern hemisphere observers. It also came at a time when astronomers were beginning to make physical studies of comets: although jets from Halley's nucleus were suggested in drawings from 1682 and 1759, this return provided the first detailed observations (by Bessel, Smyth, and Struve) of the jets' extraordinary structures. Observation period: August 5, 1835 to May 19, 1836.

Recovery, by Dumouchel in Italy, came on August 5th, some 103 days prior to perihelion passage (November 16.44); the comet was then nearly 2 AUs from the Sun. Halley was positioned a little west of Zeta Tauri and was visible in large telescopes before dawn as an object of perhaps 10th magnitude.

The comet brightened rapidly as it moved eastward. It was seen through a comet-seeker telescope by Wilhelm Struve as early as August 27th and with the unaided eye by September 17th. Its motion against the stars sped up strikingly as the distance between the comet and the Earth dwindled in early October. Halley raced across the night sky, passing from Auriga to Corona Borealis in just two weeks. Its physical development during this period was almost as astonishing.

In the first days of October, the comet transformed from a faint diffuse object, just discernible with the unaided eye, to the most conspicuous celestial body except for the Sun and Moon. In the middle of the second week of October, Halley was visible all night among the stars of the Big Dipper. The tail, which according to Struve had been a mere 80′ long on October 3rd, spanned some 20° to 25° by the 14th and the comet's head was of first magnitude. Up to 30° of tail was reported by the 19th,



1910: Glorious melodrama — but the reality was rather tame. What kinds of silliness will we see this time? Courtesy Library of Congress.

1835 A.D.

date	R.A.	Dec.	d	r	e	mag
Aug 12	05h 41m	+22.7°	2.26	1.86	55°	10.3
Sep 11	06 07	+26.7	1.25	1.42	78	7.7
Oct 1	06 48	+38.1	0.51	1.11	89	4.5
Oct 6	07 32	+48.0	0.33	1.04	87	3.3
Oct 11	11 14	+63.5	0.20	0.96	74	1.8
Oct 16	16 05	+30.0	0.22	0.89	55	1.7
Oct 31	17 22	−08.2	0.74	0.69	44	3.0
Nov 20	17 11	−16.7	1.40	0.59	21	3.7
1836 A.D.						
Jan 31	15 39	−30.3	1.54	1.56	73	5.5
Mar 21	12 00	−26.3	1.33	2.27	154	6.5
May 15	10 12	−07.7	2.59	2.96	102	8.8

but the comet's head had faded to second magnitude. In November, Halley's elongation from the Sun quickly decreased and it was lost to the evening twilight.

For observers in the Earth's southern hemisphere, Halley reappeared in the morning sky in late January. It was then unexpectedly bright, about second magnitude, although apparently displaying little or no tail. the comet's brightness declined in February and the last naked-eye sighting came shortly after mid-month. Halley was followed telescopically until May 19th when it was a faint object in Sextans.

1910 A.D.

This, the comet's 29th recorded return, was filled with unusual events — not the least of which was the appearance of a brilliant unexpected comet in the evening sky of January 1910. Known as the "Great January Comet" and preceding Halley's debut by only a few months, it was widely seen by the public and led to much confusion between the two. Halley tended to hover near the twilight regions during this return and was certainly not at its best for northern hemisphere observers. Observation period: August 25, 1909 to June 16, 1911.

For the first time, astronomers used photography to locate the returning comet. Dr. Max Wolf of Germany was first to detect Halley in early September 1909, but the comet was later found on photographs dating from late August taken at an Egyptian observatory. At Yerkes Observatory, S.W. Burnham became the first person to see the comet visually on September 17th (with the great 40-inch refractor), but few others saw it until December when it attained 10th magnitude. About this time, English amateur T.E.R. Philips began reporting striking night-to-night fluctuations in the comet's brightness.

At the beginning of 1910, Halley was an evening object about 10° north of Alpha Piscium. The first sighting with the unaided eye was claimed by Wolf on February 11th, but most observers rated it too faint (seventh or eighth magnitude) to detect without optical aid. Moonlight prevented any repeat observations before Halley descended into the twilight.

Not until mid-April, with the comet near perihelion (April 20.18), was Halley again detected. It was visible only at low altitude in the morning sky when twilight hampered observations. The generally-quoted magnitude of 2.5 for this period was possibly influenced by the unfavorable conditions. In particular, French astronomer M. Giacobini reported following Halley telescopically until *after sunrise* on April 17th, which implies a much greater brilliance.

1910 A.D.

date	R.A.	Dec.	d	r	e	mag
Jan 18	01h 32m	+09.6°	1.56	1.80	87°	9.3
Feb 19	00 45	+08.1	1.86	1.33	44	8.2
Mar 21	00 21	+08.3	1.83	0.87	10	6.1
Apr 20	23 54	+08.0	1.21	0.59	29	3.4
May 15	01 15	+14.2	0.27	0.79	32	−0.5
May 20	04 33	+19.9	0.15	0.86	11	−1.5
May 25	08 31	+09.3	0.24	0.94	65	−0.3
June 9	10 21	−00.3	0.79	1.17	79	3.1
June 29	10 47	−02.7	1.52	1.47	68	5.3

A 6° tail was noted in early May with the comet near greatest morning elongation. As Halley drew nearer to the Earth, its tail swiftly lengthened. Passing between the Earth and the Sun, Halley transited the solar disk on May 18th, with its least separation from Earth being about 13 million miles. At that time, we either closely missed or actually passed through the outer portions of the tail. Because of its proximity, the tail reached phenomenal proportions. At Yerkes Observatory, E.E. Barnard traced it through better than 100° of sky and at the midpoint it was 10° wide. Still other accounts give a stupendous 120° to 130° for its length.

As Halley moved out into the evening sky, reports indicate a magnitude of zero for the comet's head, but in all likelihood it was even brighter than this. According to C. Perrine in Argentina, at the end of May the tail still spanned 50° and the head may have been of first magnitude. The brightness seems to have dropped quickly in early June, however, for most observers reported the comet as third or fourth magnitude by midmonth. From his mountain observing site, Perrine was the last person to see Halley with the unaided eye on July 9th. Barnard, using the 40-inch refractor, continued to view the comet through April 1911 and the last photographs date from mid-June.

1986 A.D.

It's astonishing to realize that we're already three years into this return! Halley was recovered on October 16, 1982 using the 200-inch telescope on Palomar Mountain. As this issue of ASTRONOMY goes to press, it has been photographed with scopes as small as 14 inches' aperture. Who'll be the first to see the comet with the naked eye? Who'll be the *last*?

John Bortle is an active comet observer who lives in lower New York State. He runs the W.R. Brooks Observatory and has won the Comet medal of the Astronomical Society of the Pacific.

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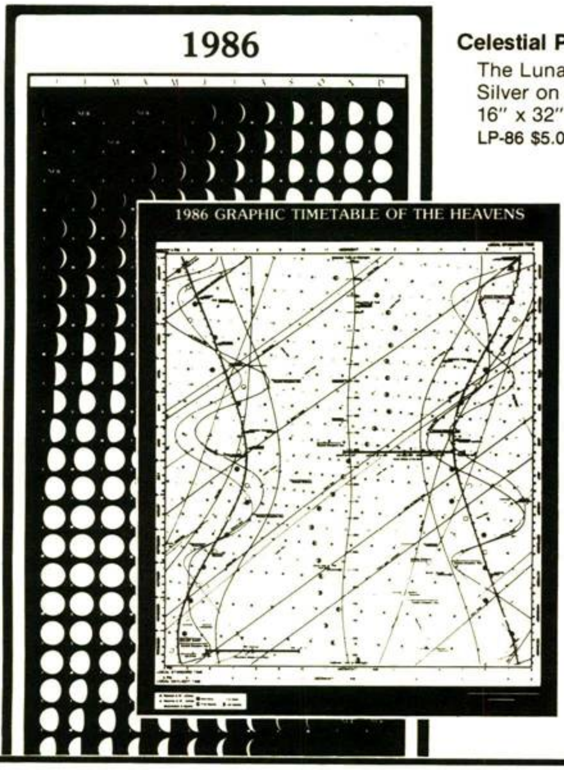

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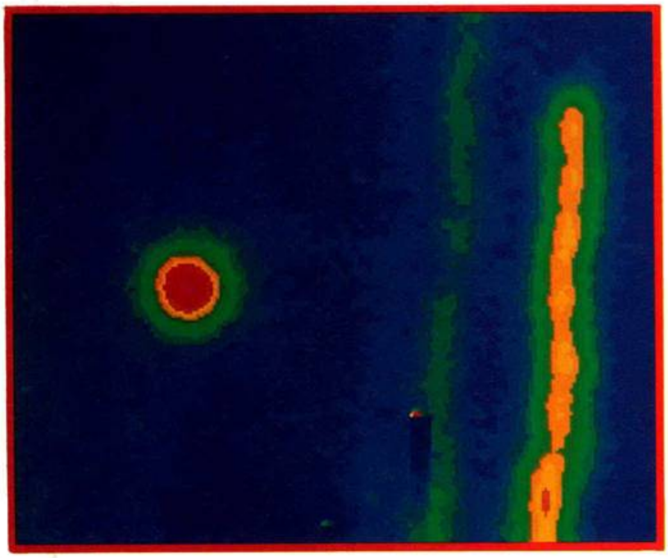
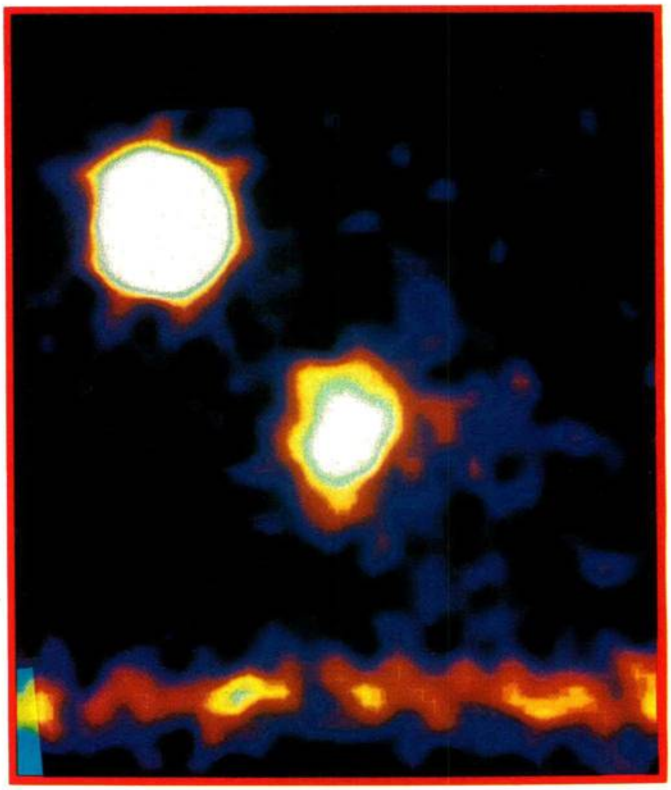
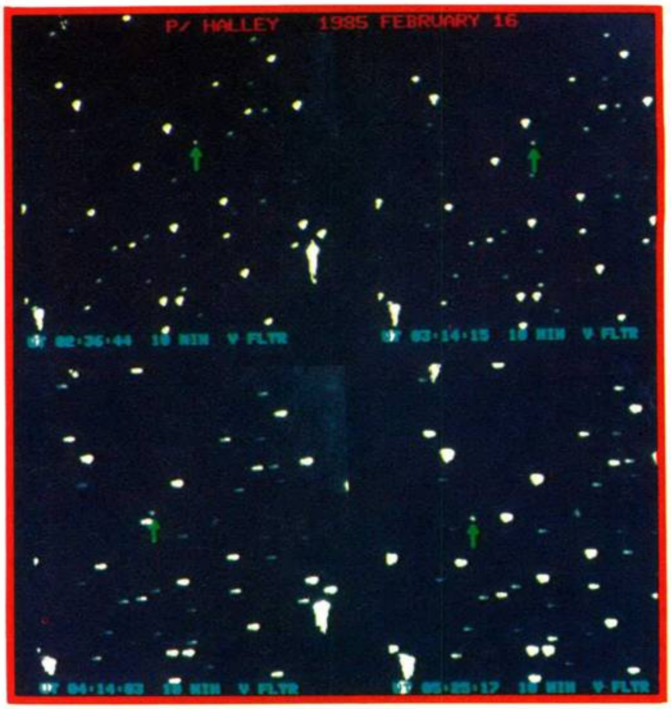
ASTRO NEWS





Clockwise, from top left: Halley recorded on 25 September 1984 using the 4-meter Mayall telescope at Kitt Peak, showing newly-developed coma; photo courtesy H. Spinrad and S. Djorgovski. Above: Halley's Comet photographed with the 4.5-meter MMT on Mt. Hopkins, Arizona, on April 18.6 UT. The coma appears 5″ across. Photo courtesy S. Wyckoff. Below: Halley on 16 February 1985 showing motion over three hours. Photo courtesy U. Fink.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Comet Halley Brightens

As this issue goes to press, Halley's Comet is beginning to make its long-awaited appearance, moving into the morning sky following its conjunction with the Sun which kept it out of sight since last April. Comet Halley now shines at magnitude 14 and has a well-developed, albeit irregular, coma. It is technically visible to anyone with a large backyard telescope under a dark sky, and is expected to brighten considerably over the next nine months before fading out of view for another 76 years.

Like all comets, Halley's behavior is difficult to predict. Imagine a frozen snowball slowly encircling a very hot light bulb: as the snowball gets close to the heat source, it begins to melt and loses material. When comets pass by the Sun, they are heated and pelted by the solar wind, and become "active." Exactly what happens when a comet heats up is difficult to say, but we know this activity serves to form a tail and brighten the comet.

Astronomers have some clues of Halley's activity from images they observed last winter and spring. The outlook isn't as good as might be wished for, because Halley should have appeared considerably brighter than it did by early August. "It appears on the dim side," says G. Edward Danielson, the Caltech astronomer who recovered Halley's Comet in December 1982. Astronomer Hyron Spinrad at the University of California said, "It just really hasn't blossomed out into a full-blown comet. By now I would have thought it might have, but that was just an explanation based on hope."

Last year astronomers discovered Halley varied rapidly in brightness — for short periods appearing as much as five times brighter than other times. This variation is probably due to a combination of the comet's rotation — exposing different parts to the solar wind — and regions of outgassing and other activity on the nucleus itself. Asoka Mendis, a research physicist at the University of California at San Diego, suggested that the changes in brightness may result from electrically-charged dust storms on the nucleus.

In the July 18 issue of *Nature*, Susan Wyckoff and her colleagues from Arizona State University published a paper describing Halley's "onset of sublimation" — the point at which it began to heat up enough to form a coma. According to Wyckoff's data — made with the Multiple Mirror Telescope on Mt. Hopkins, Arizona — Halley's Comet began warming and forming a coma at a distance of about six astronomical units from the Sun. This is supported by Spinrad and colleague Stanislav Djorgovski in California, and Michael Belton — an astronomer at Kitt Peak in Arizona — all of whom observed an extended coma at about this time.

Although Halley's Comet now appears dimmer than astronomers had hoped, it will probably put on quite a show — especially from the southern hemisphere, where it will lie higher up in the sky than in the north. Astronomers still expect the comet to reach third or fourth magnitude and develop a long tail. At this point, however, only time will tell. *David H. Levy and David J. Eicher.*

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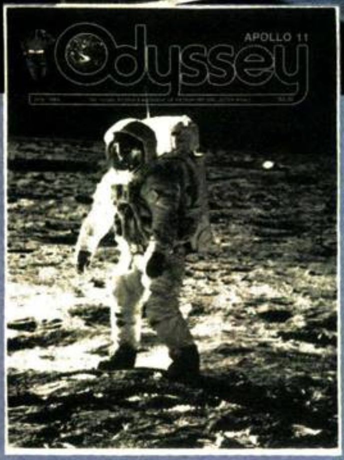

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ASTRO NEWS

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For more information or to submit a response, write the World Space Foundation, P.O. Box Y, South Pasadena, CA 91030.

Largest Supercluster Found

A newly-discovered system of clusters of galaxies has been identified as the largest known structure in the universe.

The system is located in the northern sky in the direction of the constellations Perseus and Pegasus. It lies between 200 million and one billion light-years from Earth (a light-year is the distance light travels in a year, about six trillion miles) and measures more than one billion light-years in length.

The discovery was made by Jack O. Burns, an associate professor of astronomy, and graduate student David J. Batusky, both at the University of New Mexico. Their findings will be published in the December 1, 1985 issue of *Astrophysical Journal*.

The astronomers used an electronic spectrograph on the 84-inch telescope at Kitt Peak National Observatory in Arizona. The spectrograph allowed the researchers to determine distances to the supercluster and relative positions of galaxies within it.

"This technique allowed us to recognize, for the first time, the existence of this filament," Burns said.

The largest previously reported supercluster was an assemblage of galaxies measuring about 700 million light-years long discovered in November 1982. (See AstroNews, April 1983 issue.)

Studying galaxy superclusters helps astronomers learn more about the evolution of the universe. Two theories now predominate: one holds that galaxies formed with supercluster-sized clouds of gas fragmented and condensed; another proposes that galaxy-sized structures formed first and then clustered together as the universe aged. (See "Cold Dark Matter and the Origin of Galaxies," April 1985 issue.)

"We feel quite strongly that our data favor the model in which the superclusters formed first and galaxies later fragmented from supercluster clouds," Burns said.

"With such a model, the universe must be dominated by some form of dark or unseen matter such as exotic particles predicted recently by high energy physicists."

Burns explained that for structures of this size to form, more gravitational force and thus more mass is needed than is present in stars and galaxies.

"Therefore," he said, "we must postulate the existence of a dominant component of the universe consisting of non-luminous matter."

ASTRO CALENDAR

October 5
Herstmonceux 85, 5th Annual Convention of the British Federation of Astronomical Societies, Herstmonceux Castle, East Sussex, England. Contact: Ken Marcus, 5 Cedars Gardens, Brighton, East Sussex, England BN1 6YD.

October 5
Astro-Assembly, Seagrave Memorial Observatory, North Scituate, Rhode Island. For information, send SASE to: Charles J. Lord Jr., 126 Fair St., New Bedford, MA 02740.

October 5
Telescope Users Clinic, Whittier College, Whittier, California. Contact: Bob Ferguson, Western Observatorium, 13215 E. Penn St., Suite 411, Whittier, CA 90602. Phone (818) 795-4181.

October 10-12
Joint Meeting of the Rocky Mountain Planetarium Society and the Pacific Planetarium Association, Hansen Planetarium, Salt Lake City, Utah. For information, send SASE to: RMPA Meeting, P.O. Box 3023, Boulder, CO 80307.

October 12
Ohio Turnpike Astronomers Association Convention, Mount Union College, Alliance, Ohio. Contact: David Gill, 558 Canford Ave. NW, Massillon, OH 44646. Phone (216) 833-9399.

October 17-20
Okie-Tex Star Party, sponsored by the Oklahoma City Astronomy Club, Lake Murray, Oklahoma. Contact: Joe Pearson, 700 Teal Pl., Edmond, OK 73034.

October 18-20
7th Annual Astronomy Jamboree, Custer Institute, Southold, L.I., New York. Contact: Tom Carey, Vanderbilt Planetarium, Centerport, NY 11721. Phone (516) 757-7502.

October 20-30
London Commemoration of Edmond Halley's Birthday (including visits to historical Halley's Comet sites in Europe), Wembley Conference Center, London, England. Contact: Joseph Laufer, Burlington County College, Pemberton, NJ 08068. Phone (609) 894-9311.

October 23-26
Great Lakes Planetarium Association Annual Convention, Cernan Earth and Space Center, River Grove, Illinois. Contact: Steve Bishop, Triton College, 2000 5th Ave., River Grove, IL 60171.

November 1-2
AAVSO Fall Meeting, Mt. Holyoke College, South Hadley, Massachusetts. Contact: Dr. Janet Mattei, AAVSO, 187 Concord Ave., Cambridge, MA 02138. Phone (617) 354-0484.

November 7-8
SPACE STATION: Gateway to Space Manufacturing and Services, Orlando, Florida. Contact: Anne Phelan, *Space Business News*, 1401 Wilson Blvd., Suite 910, Arlington, VA 22209. Phone (703) 528-1244 or (800) 424-2908.

November 9-10
Deep South Regional Stargaze, Percy Quin State Park, McComb, Mississippi. Contact: Frank W. Loflin II, ALCOR, Jackson Astronomical Association, 280 W. Lorenz Blvd., Jackson, MS 39213. Phone (601) 982-2388 days or (601) 856-3636 evenings.

February 7-10, 1986
Second Annual Winter Star Party, sponsored by the Southern Cross Astronomical Society, Everglades National Park, Florida. Contact: Richard A. Fagin, P.O. Box 152, Miami, FL 33197. Phone (305) 233-5165.

Meeting notices to appear in AstroCalendar must be submitted at least four months in advance of the meeting date. Most organizations appreciate your enclosing a long (business-size) self-addressed, stamped envelope along with your request for information.

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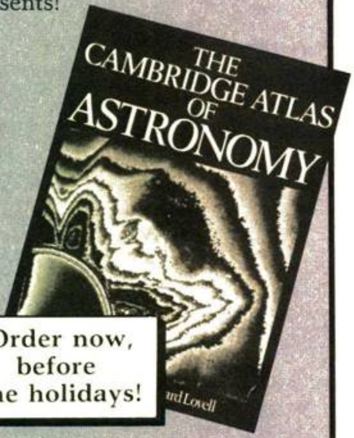

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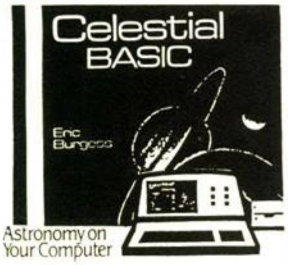

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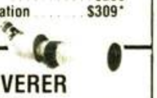

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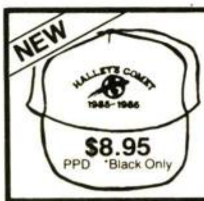

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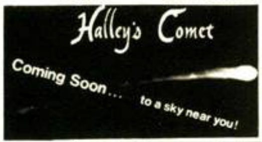
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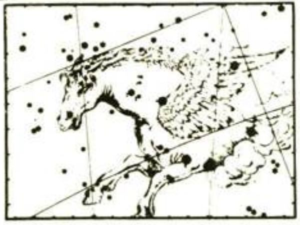

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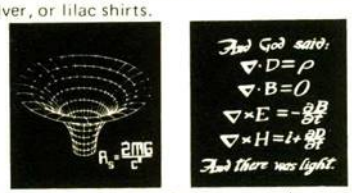
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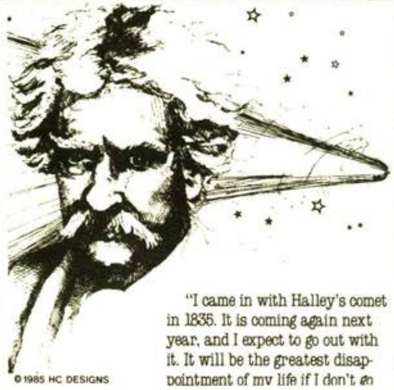

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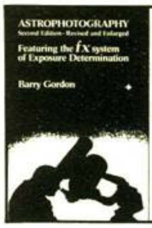
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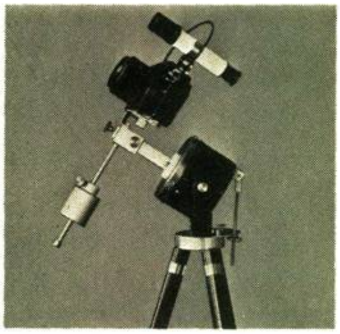

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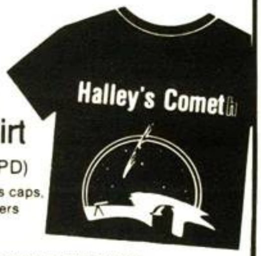

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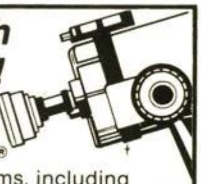

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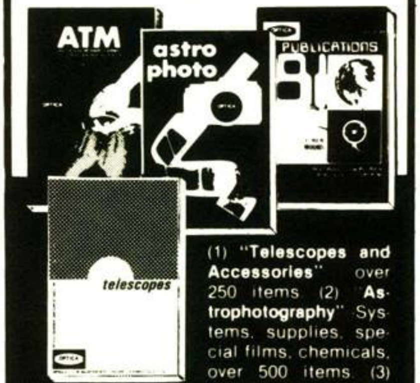

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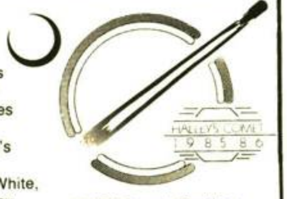

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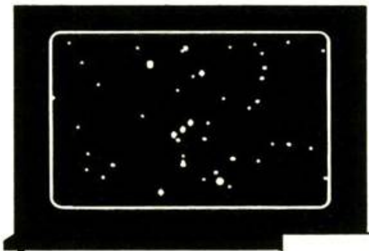

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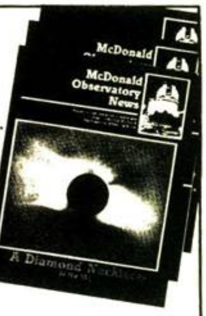

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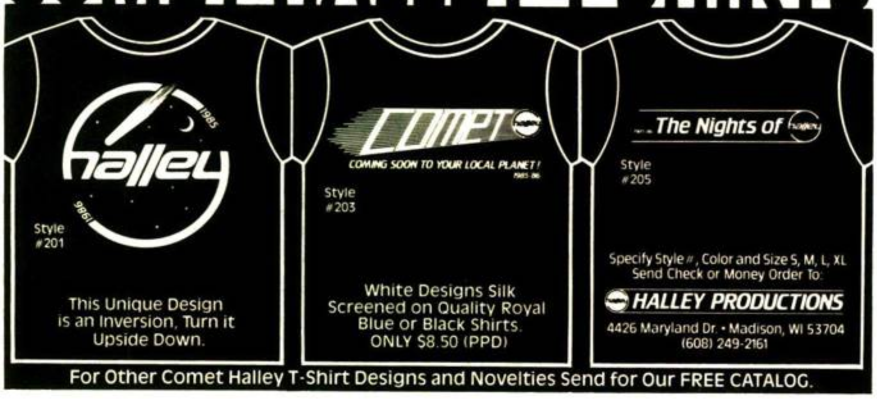

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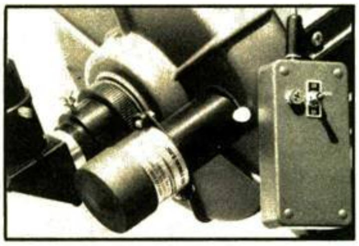

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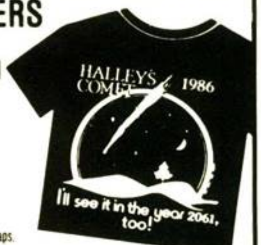
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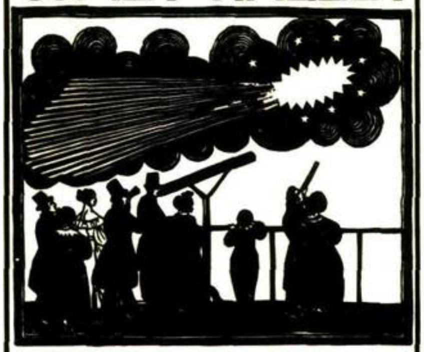

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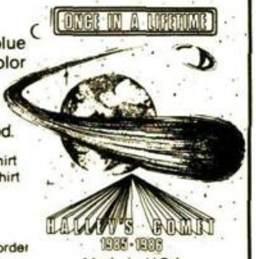

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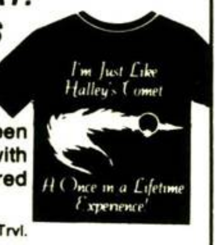

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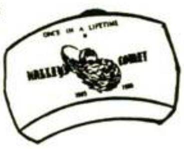

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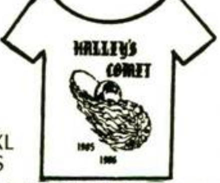

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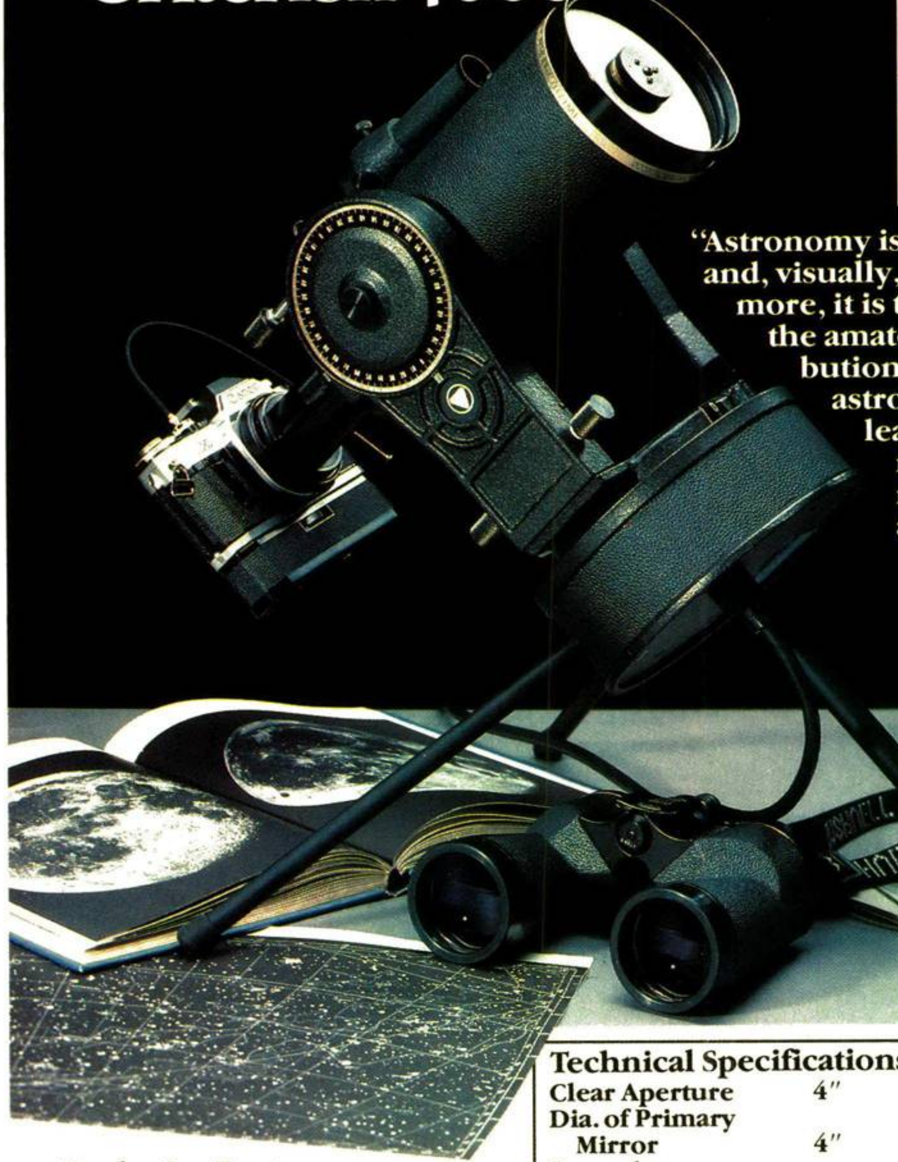

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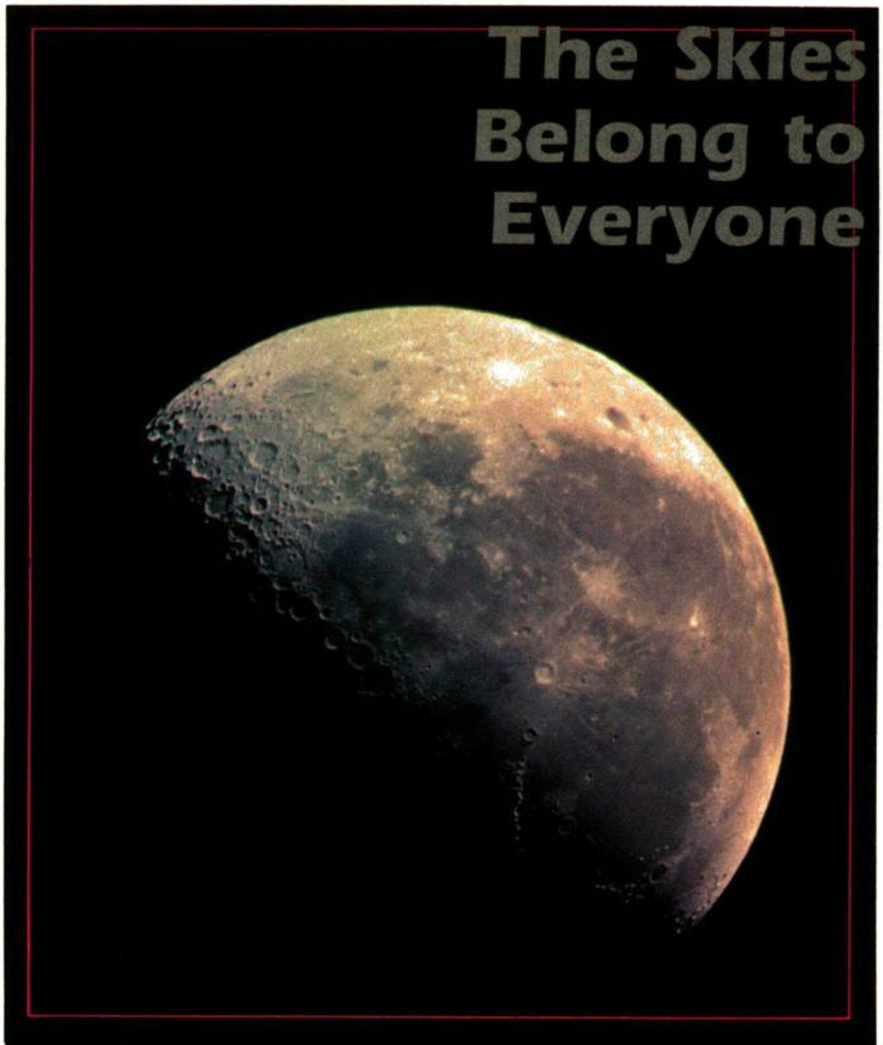


The Moon's dark basins and pockmarked, cratered highlands.

G. Terrance

So you bought a telescope to see Halley's Comet. Or at least heard all the Halley hoopla, went outside, looked up, and became entranced by the stars. You're entering the world of backyard astronomy at an exciting time — one in which you can see the sky's most famous visitor. But what happens after next April, when Mr. Halley's famous snowball recedes into the darkness? Not to worry — there are moons, planets, stars, comets, nebulae, and galaxies, many of which are visible to users of small telescopes on any clear night.

There's no better way to start in astronomy than with the Moon. The brightest and largest object in the nighttime sky, the Moon is covered with features easily visible in binoculars or small telescopes. You can actually see some lunar features with your unaided eye, most notably the dark lunar lowlands — vast plains of congealed lava — called *maria* (from *mare*, Latin for sea). Indeed, the "Man in the Moon" comes from several large maria that form a dark "face." The most striking patches of darkness visible against the Moon's brilliant surface are Oceanus Procellarum and Maria Imbrium and Nubium on the western side, and Maria Serenitatis, Tranquillitatis, Nectaris, Fecunditatis, and Crisium on the eastern side.

To see anything of the Moon beyond its great "seas," however, your eyes need help. Binoculars show the maria in better detail along with a few prominent craters. Better still, a small telescope working at about 60x makes the Moon come alive with features: the craters Plato and Copernicus straddle Mare Imbrium, itself partially encircled by a broken chain of mountains called the Apennines; the pockmarked central highlands feature densely concentrated craters scattered pell-mell; Mare Nubium hides the "Straight Wall," a gigantic cliff visible only when illuminated from the right angle.

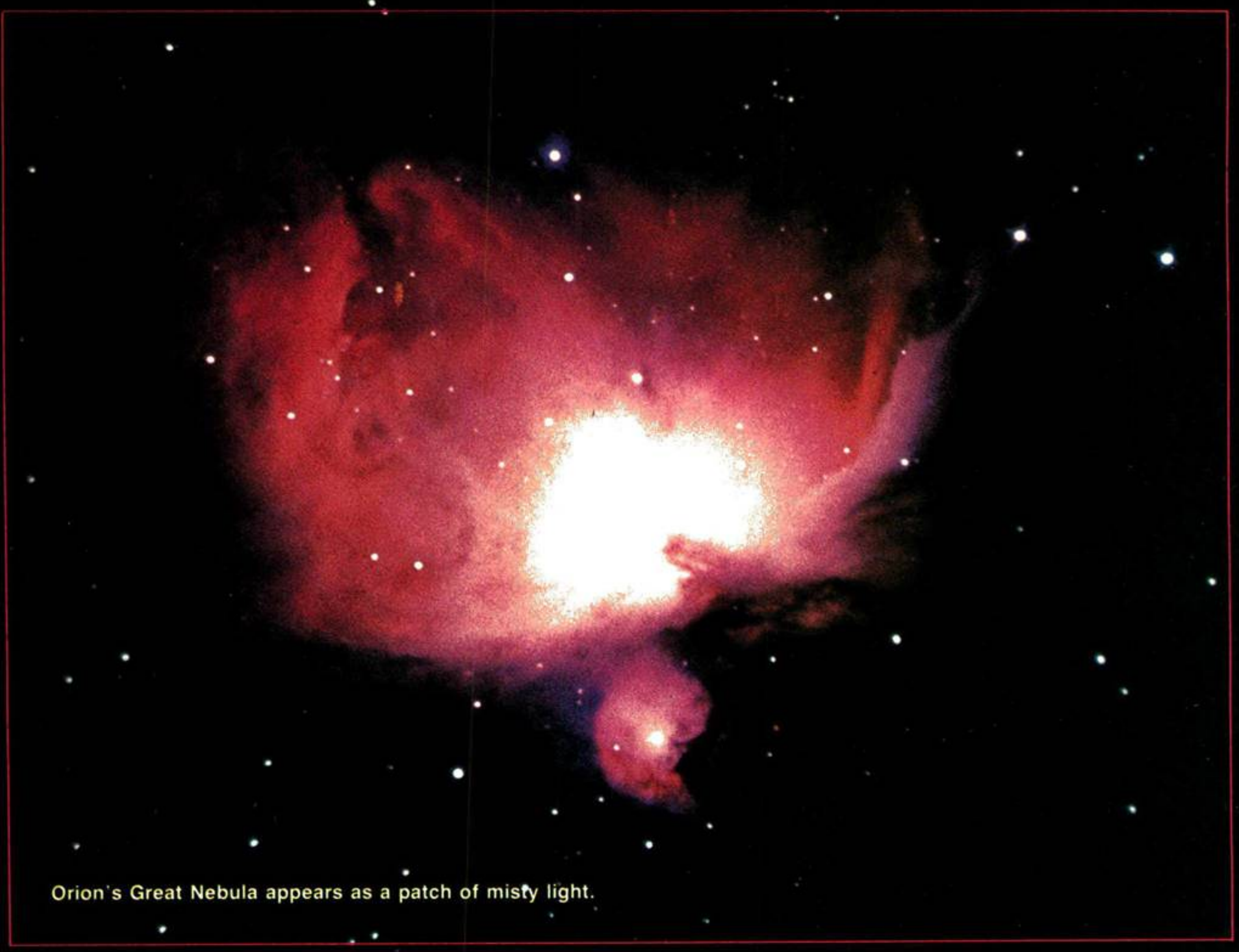
There is an enormous amount to see on the Moon — a few nights observing it will surely convince you of that. Try watching over successive evenings, and observe how features change as the Sun journeys slowly through the stark lunar sky — its rays passing across craters, hills, and valleys. At sunrise, shadows are long and black — every little detail stands out clearly. Then, as the Sun climbs higher, shadows shorten and the terrain appears to flatten. At Full Moon, craters disappear in the hot glare of noon. As the phase shifts toward Last Quarter, the evening terminator — the line between day and night — crawls westward, painting the rugged topography with shadows once more.

The Moon is only the beginning of what the solar system has to offer. There are eight planets visible in backyard telescopes, seven of which are also visible in binoculars. The planet that orbits nearest to the Sun, Mercury, is bright but never appears very far from the Sun in the sky. You must always look for it right before sunrise or soon after sunset. Mercury is small and distant enough that binoculars and telescopes show it as just a tiny, orange-colored dot of light in the twilit sky.

Venus, however, is another story. It is both the "morning star" and the "evening star." Save for the Sun and Moon, Venus is the brightest object in the sky. Its orbit lies inside Earth's orbit, so it always appears close to the Sun in the sky, rarely straying more than 50° — two handspans — away. Because it orbits between the Earth and Sun, we can observe Venus in different phases of illumination just as we do the Moon.

Mars lies farther away from the Sun than Earth, so to us it almost always looks "gibbous" or "Full." It is bright and easy to locate, however, and offers something to small telescopes that neither Venus nor Mercury can — subtle surface markings. Binoculars show Mars' ruddy color well, but don't provide enough magnification to show its disk. A telescope operating at 75x to 100x magnification is required. Under ideal conditions, a 3 or 4-inch scope shows several dark markings against the creamy orange surface, the most prominent of which is Syrtis Major, a triangular rocky plateau near the martian equator. Also visible at times are the polar caps, although their relatively low contrast demands a keen eye.

The solar system's giant planet, Jupiter,

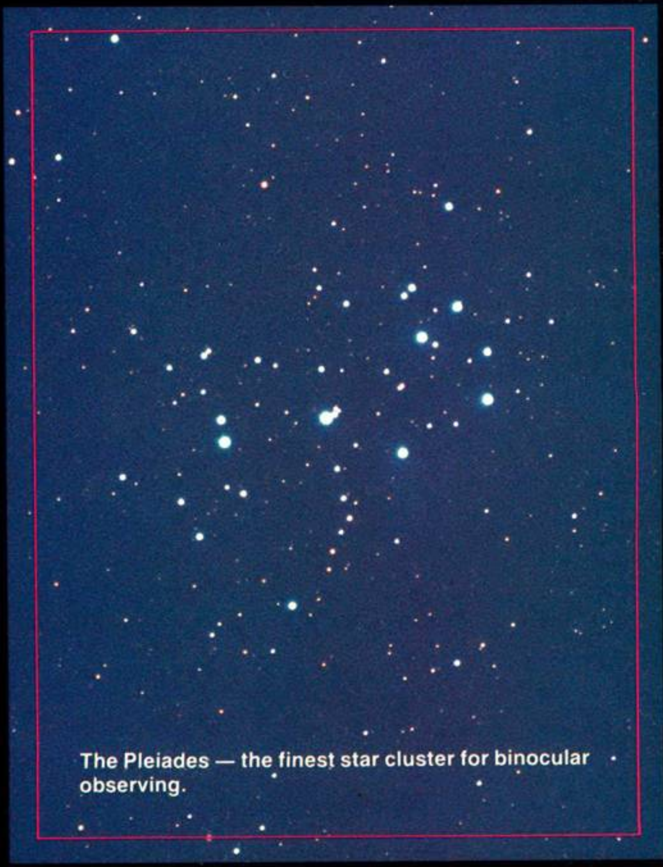


Orion's Great Nebula appears as a patch of misty light.

Jack B. Marling

Jupiter reveals colorful cloud bands and its Great Red Spot.

Donald C. Parker



The Pleiades — the finest star cluster for binocular observing.

Conrad L. Kussner

Bright comets, like 1976's Comet West, have blue gas tails and yellowish dust tails.

Robert Provin

is enormous — so huge it could hold 1000 Earths. Jupiter is fascinating in a telescope or even 6x binoculars. Its four brightest moons — Io, Ganymede, Europa, and Callisto (each as big as Earth's own Moon) — line up alongside the planet. Even when viewed through binoculars, Jupiter appears as a little disk and its four bright moons appear as specks of light. On successive nights, check Jupiter with binoculars and you'll discover that the four specks change positions around the planet. This is exactly what Galileo observed nearly 400 years ago, confirming that Jupiter's moons circle the planet just as the planets encircle the Sun.

Viewed with a small telescope, Jupiter is a memorable sight. The most prominent features are cloud bands — gigantic swirling clouds which most often appear in a variety of tawny shades moving rapidly along the planet's creamy-white "surface." But these are not the only visible feature. At the right time, Jupiter's Great Red Spot — a huge storm several times the size of Earth— is observable as a pale orange oval.

Perhaps the most striking sight in backyard astronomy is that of Saturn, the golden-orange ringed world beyond Jupiter. Binoculars show Saturn as a tiny ellipse (the rings) with a faint "star" nearby (its brightest moon, Titan), but you really need a magnification of 75x or 100x to do Saturn justice. With a small telescope, you'll see what many first-time observers believe is an indescribable sight: a bright oval orange globe, perfectly encircled by pale, sharply-defined rings. And Titan — along with two or three other moons — is visible if you know which speck of light to look for.

Beyond Saturn, the solar system contains two more "gas giants" — Uranus and Neptune. Although large planets, they look faint and small because of their great distance. Both are visible in binoculars, appearing as bluish-green dots distinguishable from stars only by their color and position. In a 3 or 4-inch telescope at high power, you see Uranus and Neptune as tiny disks. Significantly fainter still, Pluto — the outermost planet in the solar system — is visible as a faint speck of light only on the very best nights with large telescopes.

Every once in a while and usually completely unexpectedly, a bright comet sweeps in near the Sun and becomes the sky's most commanding sight — temporarily. There are also many periodic comets, including Halley's, that return at regular intervals and whose orbits are well known. In either case, bright comets can be the most detailed of the solar system's objects as viewed in binoculars or small scopes. Such comets aren't common, but during the last decade bright ones appeared in 1975 (Comet Kobayashi-Berger-Milon), 1976 (Comet West), and 1983 (Comet IRAS-Araki-Alcock). Maybe you've heard of them. When a bright comet does fly by, even hand-held

The Andromeda Galaxy — visible to the naked eye under a dark sky.

David Healy

binoculars show its nucleus, coma (a diffuse cloud of gas surrounding the nucleus), and gas and dust tails.

Looking beyond the family of the Sun, we take a long step into deep space. Stars, like people, come in many sizes, types, and ages. The majority of stars, in fact, are not alone. Just as the Sun has planets, some stars have other stars. Many of these double star systems are conveniently placed for small telescope observing. Albireo (Beta [β] Cygni), for example, is the bright star marking the beak of Cygnus the Swan — a prominent constellation in summer and fall skies. Small telescopes quite easily show that this star — a single point of light to the naked eye — is made up of a bright yellowish star *and* a slightly dimmer blue companion. These stars orbit about a common center of mass and travel together through space. The inky black gap between Albireo's two stars is so wide you could fit 10 solar systems within it.

Stars vary in behavior. Some change their brightness or size over time. These are variable stars and they, too, are within the capability of backyard telescopes. Observing variable stars is rather tricky as you must adjust your eyes to the subtle differences in various stars' brightnesses. But for a start, look at the star Mira (Omicron [ο] Ceti) each time you're out watching Comet Halley. It's marked on ASTRONOMY's Star Dome and virtually all star atlases. You may not see a star where Mira is supposed to lie — if so, Mira is near minimum brightness. Or you may see a bright star precisely where Mira is shown on the map. If so, keep watching it. Over a period of several weeks, Mira will fade to below naked-eye visibility, and then weeks later rise back to where you can again see it. With binoculars or a telescope, you can follow Mira's entire cycle of variability.

Stars form in groups as giant gas clouds collapse inward and compress the matter into dense, hot clumps. The process of stars exploding and creating gas clouds and gas clouds collapsing back into new stars is ongoing, so anyone with a small telescope can go outside anytime and observe clusters of young stars and nebulae — interstellar gas clouds. A fine open cluster of young stars is the Pleiades, a large, dipper-shaped group in the constellation Taurus. Visible during late fall and winter, the Pleiades is composed of six bluish-white stars bright enough to see without telescopic aid. But try it with a telescope: you'll see several hundred stars. The other type of star cluster, a globular cluster, is typically a spherical ball of old stars lying outside our Galaxy's disk. A fine example is M-15 in the constellation Pegasus. Viewed with binoculars, this collection of perhaps half a million stars appears as a tiny, fuzzy disk of gray light. A backyard telescope at high power reveals a soft glow composed of thousands of stars, a few of which appear resolved toward the cluster's edge.

Far beyond our own Galaxy lie other galaxies — individual isolated "island universes" of stars, gas, and dust. The nearest large galaxy to our Milky Way is M-31, the Andromeda Galaxy, a spiral-shaped galaxy visible to the unaided eye as a fuzzy elongated patch of light. Located 2.3 million light-years away, it is the most distant object visible to the naked eye. (One light-year, the distance light travels over the course of one year, equals approximately six trillion miles.) Some clear night this fall, go outside and locate the constellation Andromeda. Look carefully near the star called Nu (ν) Andromedae and you should detect a faint patch of light. Now train your binoculars or telescope on that patch of light: you'll see a bright oval center surrounded by a faint haze. This haze is the light from M-31's spiral arms.

Our Milky Way Galaxy, a collection of 100 billion stars, is but one of several hundred billion galaxies comprising the whole universe. We can't see them all — they're too far away — but just thinking about them is pretty awesome.

Our abbreviated tour discussed only a few of the sky's sights — but a small telescope under a good dark sky is capable of showing thousands of celestial objects. Backyard astronomers do more than simply observe the heavens, though. There's astrophotography, an entire field built around recording the magnificence of the universe on film. (See "Photography in Astronomy," page 58 of this issue.) There's also amateur telescope making, a hobby within a hobby in which dedicated craftsmen study optical designs and construction techniques to produce one-of-a-kind homebuilt telescopes. And there are numerous local and several national astronomical societies — groups in which novices can gain immensely useful insight from "old pros" and stay in touch with what's happening in backyard astronomy.

If you find yourself interested in "this astronomy thing" but aren't quite sure about it — not to worry. Get outside this fall, enjoy the comet while you can see it, and take time to simply stand under the stars and look at them. If you get a relaxed, philosophically-curious feeling — watch out! You may be in for one of the most enjoyable, enlightening experiences of your life. You may be turning into a backyard stargazer.

— *David J. Eicher*

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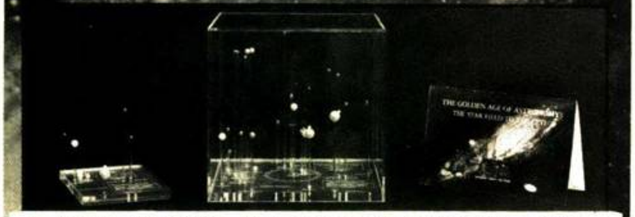

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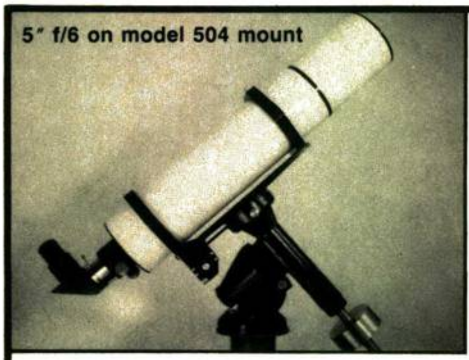

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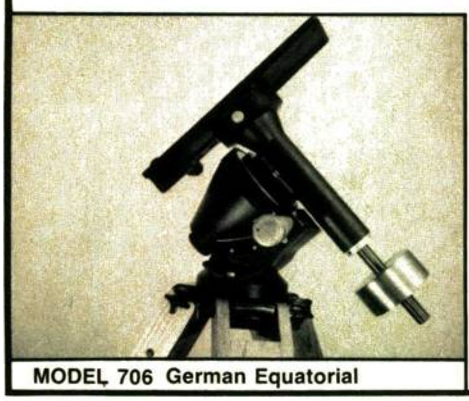

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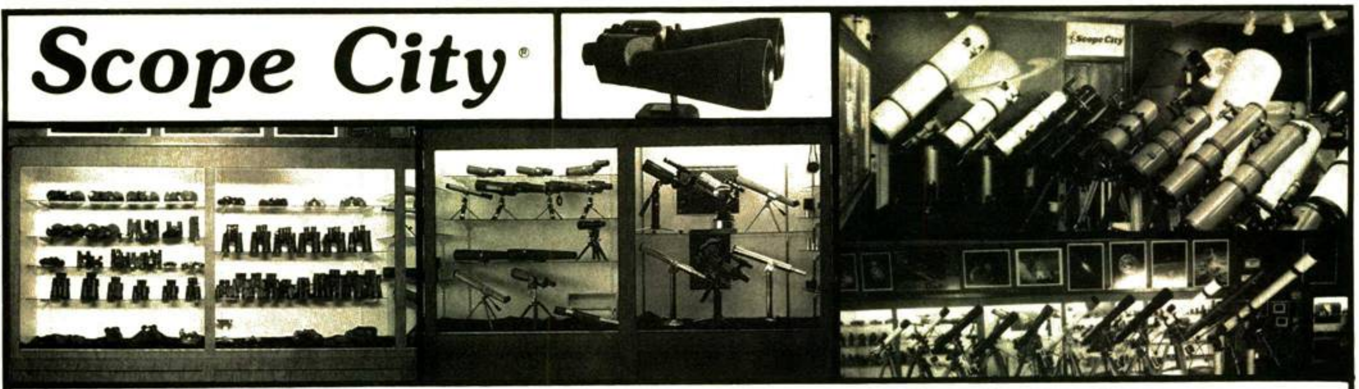

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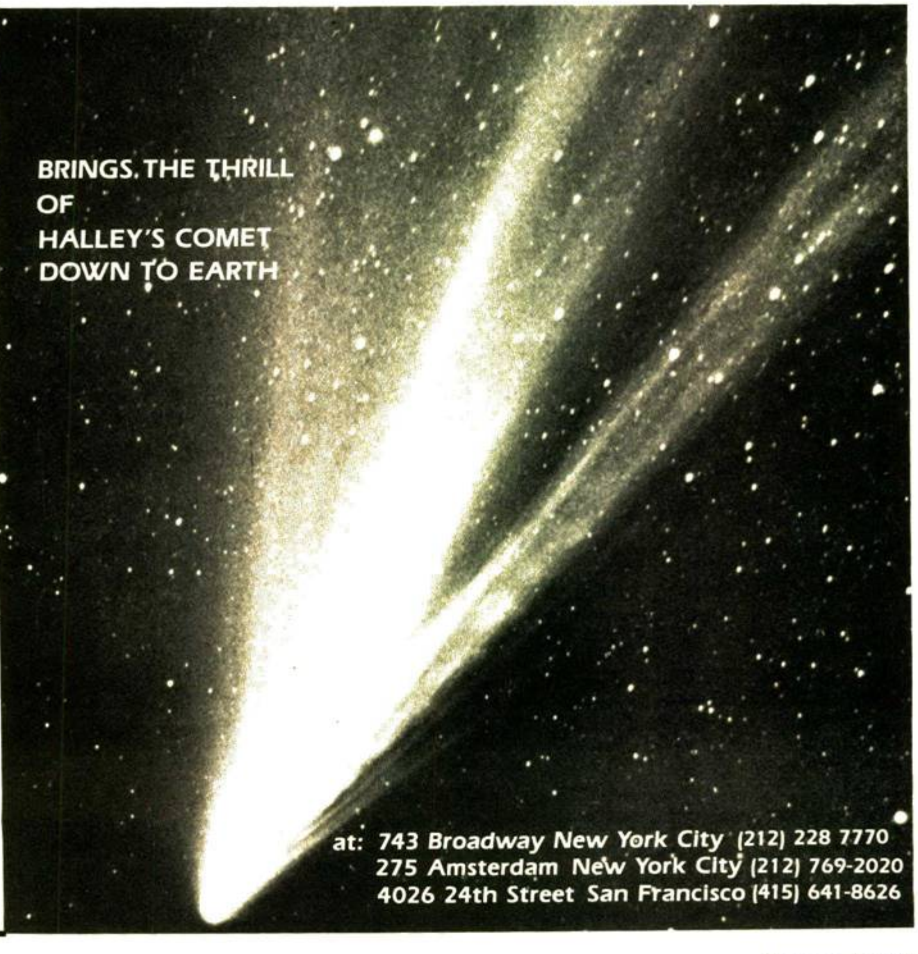

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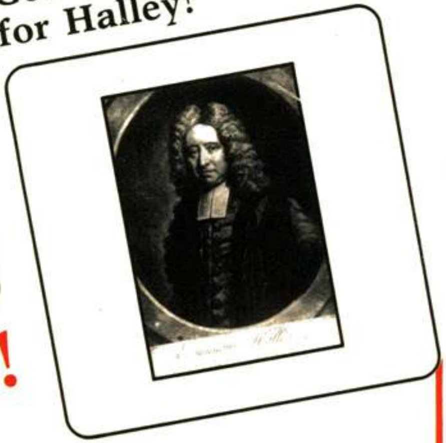

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a slide set by John C. Brandt

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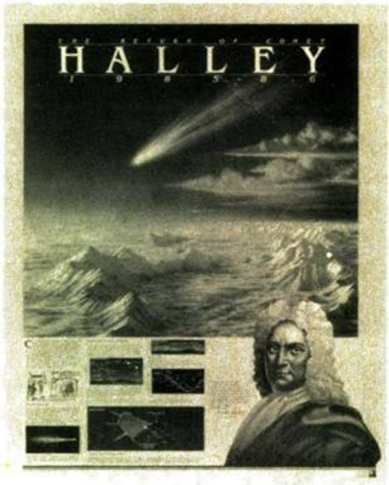

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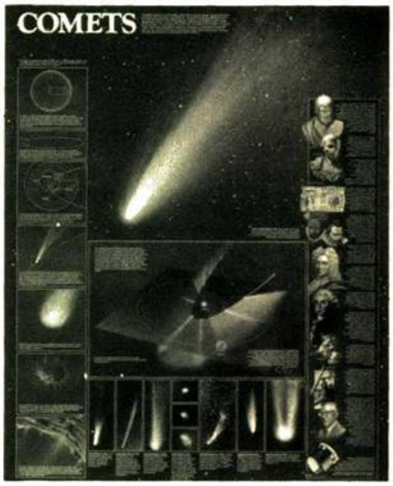

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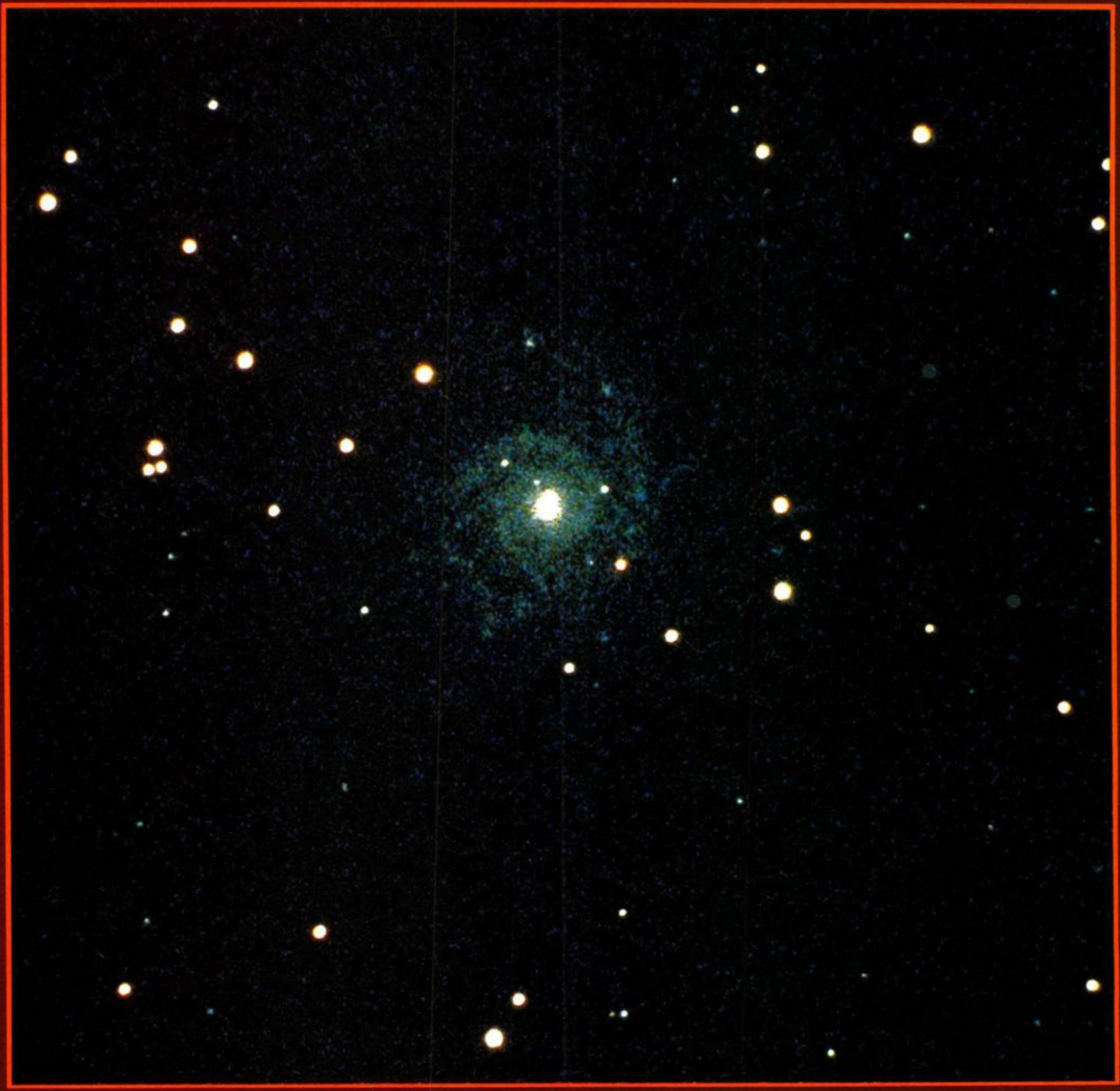


Above: Although it has a low surface brightness, M-74 is one of the finest face-on spiral galaxies in the sky. Photo by Bill Iburg. Left: One of Pisces' best double stars, Zeta (ζ) Piscium can be ''split'' in almost any telescope.

Pisces

Psc
Piscium

Keith Ward

Although devoid of other types of deep-sky objects, **Pisces** the Fish — located on the ecliptic between Aries and Aquarius — is a constellation rich in galaxies.

By far the best of the lot is **Messier 74** (NGC-628), a large faint face-on spiral lying between the bright stars Eta (η) and 105 Piscium. M-74's total magnitude is 9.2, but its light is spread over an area measuring 10.2′ x 9.5′ — making its overall surface brightness rather low. In fact, if the Moon is out or the transparency mediocre, you may have trouble spotting M-74 with a small telescope. On a good night, however, a 4-incher shows this galaxy as a pale circular glow of uniform light. A 6-inch scope reveals the nucleus as bright and slightly condensed, while a 10-inch telescope shows the nucleus surrounded by a mottled, patchy haze representing the spiral arms. Despite its faintness, M-74 is one of the nearest face-on spirals — only 10.6 megaparsecs away. It is about the same size as the Milky Way, but has a far lower luminosity so that it appears dim.

Pisces contains a large number of NGC galaxies south of the M-74 area. The brightest of these is **NGC-488** — a nearly face-on Sb galaxy featuring tightly-wound spiral arms. With a 6-inch scope, this galaxy appears as a roundish patch of fuzz, but a 10-incher at high power shows a bright ball-like nucleus surrounded by a moderately-concentrated glow encapsulated by a smooth, faint envelope of fuzzy light. Larger scopes accentuate the galaxy's compact nucleus and reveal a hint of mottling, which suggests spiral arms. NGC-488 shines at magnitude 10.3 and measures 5.2′ x 4.1′ across, making it visible as a nebulous patch in virtually any telescope.

An odd distorted galaxy in Pisces is **NGC-520**, also known as number 157 in astronomer Halton Arp's *Atlas of Peculiar Galaxies*. Although unspectacular as viewed with a backyard telescope, photographs show NGC-520 is a badly-distorted galaxy undergoing violent disruption; a 10 or 12-inch scope under a dark sky reveals the galaxy's strange, box-like shape. A 17.5-inch scope at high power shows uneven illumination across the galaxy's face and a wispy halo of nebulosity around the main body. A magnitude 11.2 object, NGC-520 measures 4.8′ x 2.1′ and is even visible in large finder telescopes under good conditions.

The brightest elliptical galaxy in Pisces is **NGC-524**, a magnitude 10.6 nebulous disk measuring 3.2′ across. Although it has a fairly high surface brightness, NGC-524 is virtually featureless in backyard telescopes — large scopes show a slight concentration toward the galaxy's center, but that's all. On nights of poor seeing, small scopes (in the 2-inch to 4-inch range) may not even distinguish the galaxy from the brightest field stars. Try to observe this and other galaxies on cool, crisp nights under a dark moonless sky.

About 3½° due north of NGC-524 is the roundish Sc-type galaxy **NGC-514**, a much better sight in most telescopes. Measuring 3.5′ x 2.9′ and shining at magnitude 11.9, NGC-514 is visible in a 4-inch telescope as a spot of nebulosity. A 6-incher at high power shows a condensed nucleus spanning about 30″ across surrounded by a smooth faint glow.

The remaining galaxies in Pisces lie toward the western end of the constellation. **NGC-95** is a faint Sc-type spiral barely visible in 4-inch scopes as a tiny nebulous patch. Although it measures only 1.9′ x 1.5′ and glows dimly at magnitude 12.6, NGC-95 is identifiable as a galaxy in 6-inch or larger scopes on dark nights. A 10-inch instrument shows the galaxy's bright, condensed core and low surface brightness haze. If you have trouble spotting NGC-95, use medium magnification — say, 12x per inch of telescopic aperture — and slowly sweep the telescope back and forth. Averted vision should enable you to pick out the nebulous patch as you come across it.

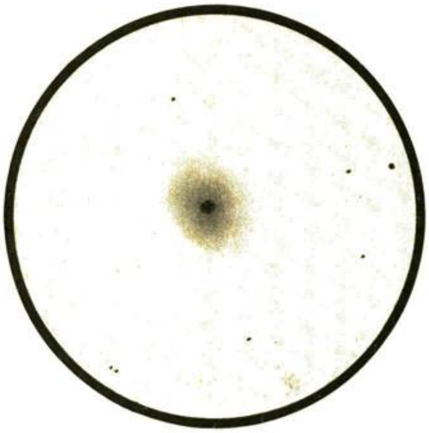
NGC-128 is a bright lenticular galaxy visible in nearly any telescope. Its dimensions of 3.4′ x 1.0′ and magnitude of 11.6 make it appear as a thin spindle of bright light in a 6-inch scope. A 10-incher reveals a bright star-like nucleus and high surface brightness "spike" of nebulosity surrounded by a faint halo. Although not among the brightest of the sky's lenticular galaxies, NGC-128 is an appealing sight and easy to locate.

Two final galaxies lie on the extreme western end of Pisces — NGC-7541 and NGC-7679. **NGC-7541** is a 12th magnitude Sc-type spiral measuring 3.5′ x 1.4′ across; it is visible as a small oval smudge of nebulosity in a 4-inch scope on a dark night. **NGC-7679** is a 13th magnitude spiral spanning only 1.9′ x 1.3′. Scopes in the 2-inch to 4-inch range

For information on naked-eye sky viewing, including planets, constellations, and mythology, see **Eye on the Sky**.

NGC-488

8-inch f/10 SCT
50x



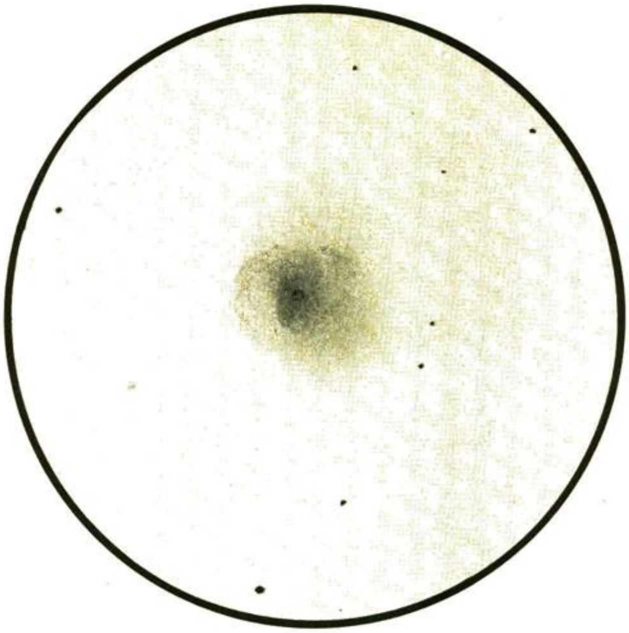
barely distinguish it from a star, while a 10-inch instrument clearly shows the galaxy as an elongated ball of fuzzy gray light.

Pisces holds two splendid double stars for small telescopes, the brightest of which is **Alpha (*α*) Piscium**, a fairly close pair requiring high power for a clean split. The primary is a magnitude 4.3 star of spectral type A2, while the secondary — some 1.9″ away in p.a. 292° — is a magnitude 5.2 spectral type A3 star; both appear bright bluish-white. The other double star is **Zeta (*ζ*) Piscium**, a much easier pair to separate. Zeta's components are magnitudes 4.2 and 5.3 stars separated by 23.6″ in p.a. 63°. The primary is a type A5 while the secondary is a dF6; they are most often observed as pale yellow and pale rose in color.

The easternmost member of the large asterism called the "Circlet" is **TX Piscium**, an odd irregular variable star. Also known as 19 Piscium, TX is strongly red colored and a so-called carbon star, showing strong bands of carbon in its otherwise typical cool red giant spectrum. The star varies between magnitudes 6.9 and 7.7 over erratic periods, but is most curious because of its deep ruddy tint. In contrast, compare it with nearby 21 and 25 Piscium, both bright bluish-white stars.

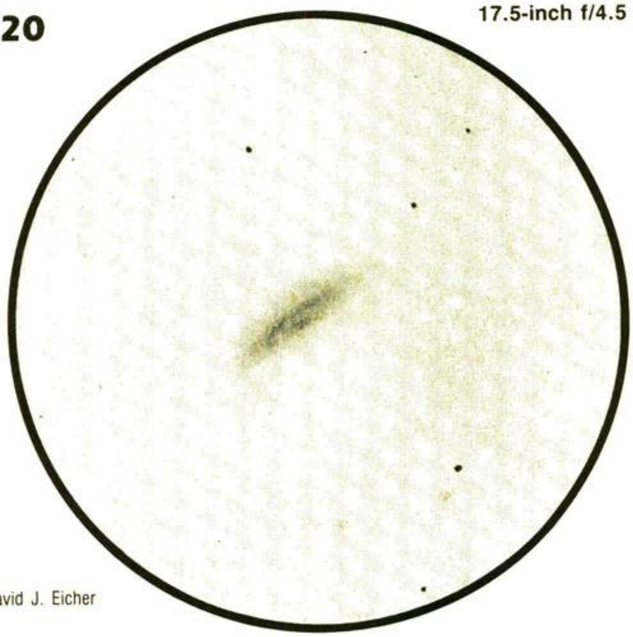
M-74

17.5-inch f/4.5 reflector
71x



NGC-520

17.5-inch f/4.5 reflector
71x

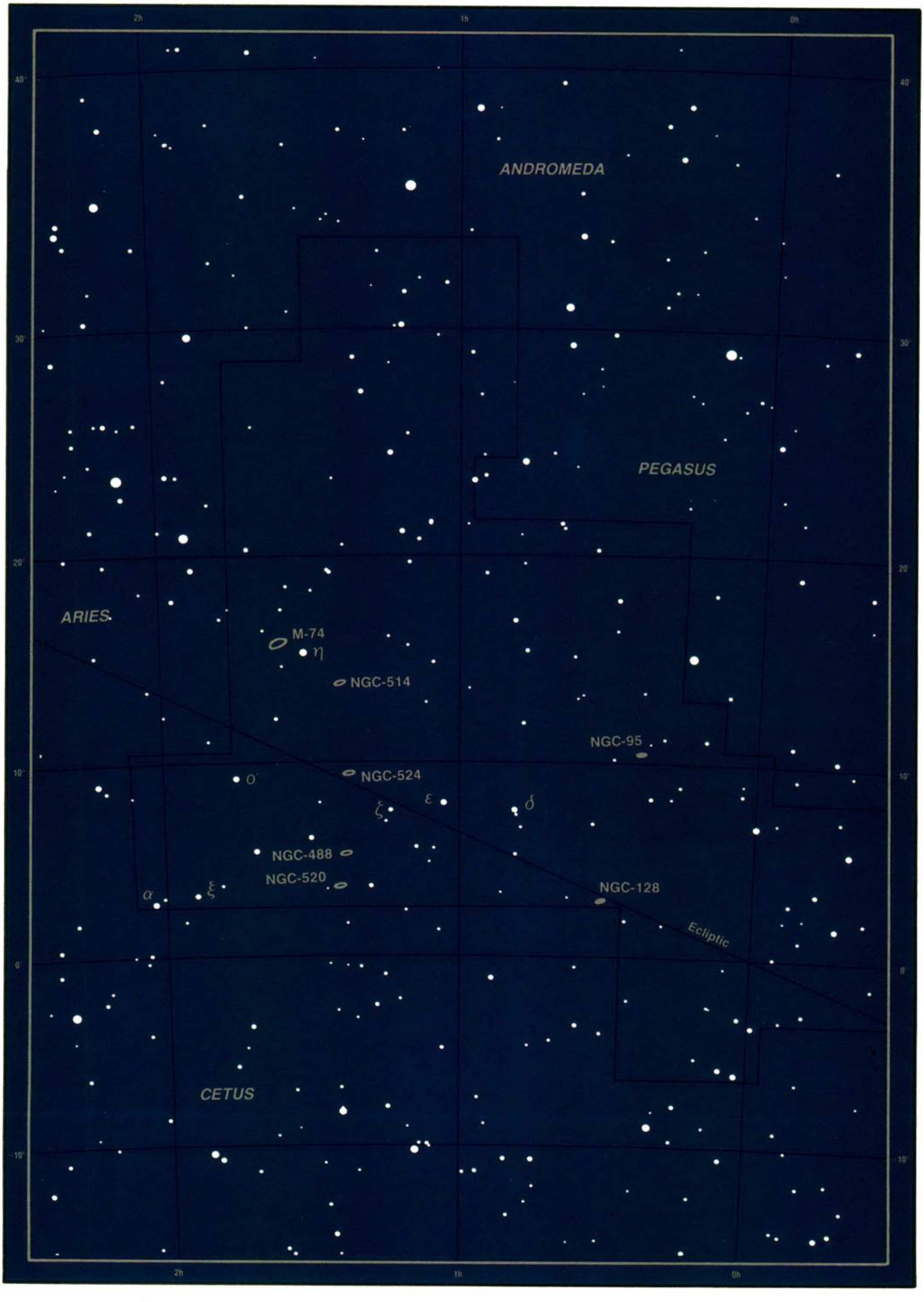


Sketches by David J. Eicher

Object	M#	Type	R.A. (2000) Dec.	Mag.	Size/Sep./Per.	H
NGC-95		§	0h 22.2m +10°30′	12.6	1.9′x1.5′	Sc
NGC-128		§L	0h 29.3m + 2°52′	11.6	3.4′x1.0′	S0
ζ		★^{2}	1h 13.7m + 7°35′	4.2,5.3	23.6″	
NGC-488		§	1h 21.8m + 5°15′	10.3	5.2′x4.1′	Sb
NGC-514		§	1h 24.1m +12°55′	11.9	3.5′x2.9′	Sc
NGC-520		#	1h 24.6m + 3°48′	11.2	4.8′x2.1′	P
NGC-524		0	1h 24.8m + 9°32′	10.6	3.2′x3.2′	E1
NGC-628	M-74	§	1h 36.7m +15°47′	9.2	10.2′x9.5′	Sc
α		★^{2}	2h 02.0m + 2°46′	4.3,5.2	1.9″	
NGC-7541		§	23h 14.7m + 4°32′	11.7	3.5′x1.4′	Sc
NGC-7678		§	23h 28.8m + 3°31′	12.7	1.9′x1.3′	S
TX		IV	23h 46.4m + 3°29′	6.9↔7.7	Irr	

H = Hubble classification type for galaxies

★^{2}	*Double Star*
IV	*Irregular Variable*
#	*Peculiar Galaxy*
0	*Elliptical Galaxy*
§	*Spiral Galaxy*
§L	*Lenticular Galaxy*



2h
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40°
30°
20°
10°
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-10°
ANDROMEDA
PEGASUS
ARIES
M-74
η
NGC-514
NGC-95
NGC-524
ο
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NGC-488
NGC-520
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NGC-128
Ecliptic
CETUS
2h
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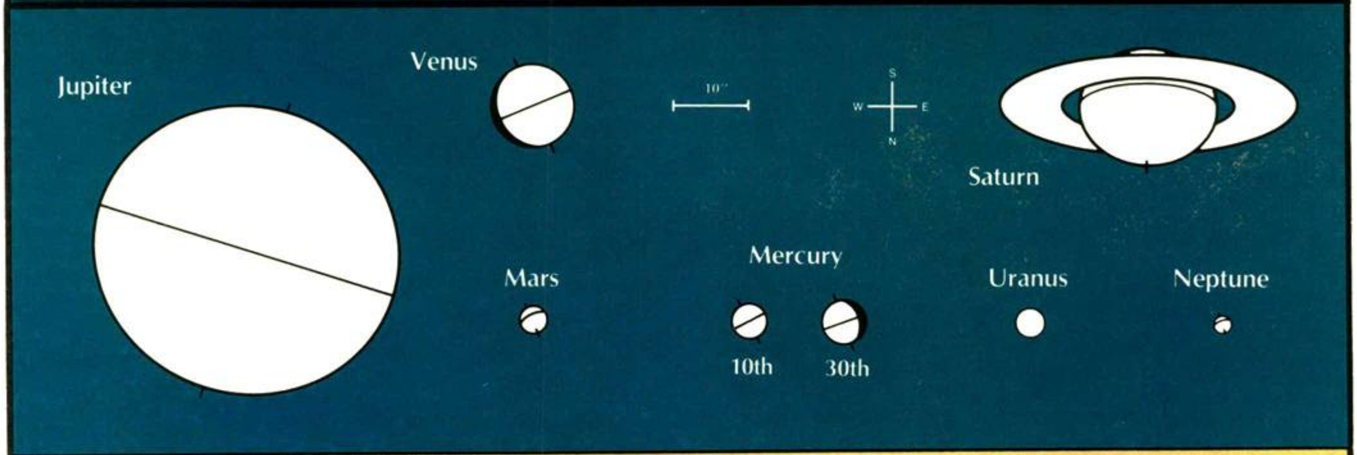
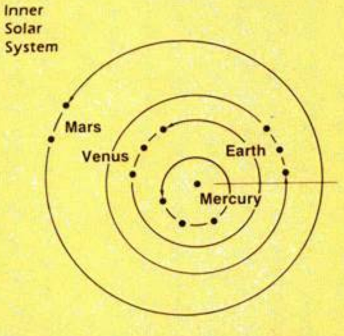
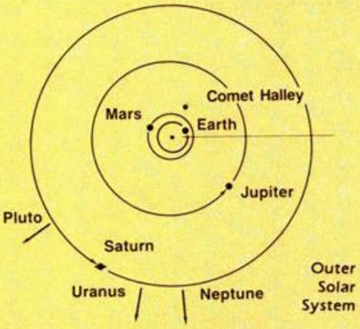
Planetary Data

October 1985


Jupiter
Venus
10″
S
W
E
N
Saturn
Mars
Mercury
Uranus
Neptune
10th
30th

		Date	Mag.	Angular Size	% Illum.	Distance (AU) from: Earth	Sun	Longitude: Heliocentric	Ecliptic	R.A. (2000.0)	Dec.
Sun		1	−26.7	32.0′	—	1.00	—	—	187°46.0′	12h 29.2m	− 3°09.4′
		15	−26.7	32.1′	—	1.00	—	—	201°35.3′	13h 20.5m	− 8°29.3′
		31	−26.8	32.3′	—	0.99	—	—	217°31.0′	14h 21.4m	−14°05.0′
Mercury	☿	1	−1.0	4.8″	99%	1.41	0.43	209°01.7′	194°16.4′	12h 53.7m	− 4°59.1′
		15	−0.4	5.0″	92%	1.35	0.47	249°58.1′	216°39.6′	14h 16.2m	−14°35.9′
		31	−0.2	5.8″	78%	1.17	0.44	295°26.3′	239°16.4′	15h 46.1m	−22°23.3′
Venus	♀	1	−3.9	11.5″	88%	1.45	0.72	121°42.7′	161°03.5′	10h 51.9m	8°31.8′
		15	−3.9	11.0″	92%	1.51	0.72	144°27.8′	178°18.5′	11h 56.1m	2°03.2′
		31	−3.9	10.6″	94%	1.57	0.72	170°27.3′	198°10.9′	13h 09.4m	− 5°41.6′
Mars	♂	10	1.8	3.8″	98%	2.48	1.67	152°44.0′	169°07.6′	11h 21.9m	5°25.2′
		20	1.8	3.8″	98%	2.43	1.67	157°06.1′	175°25.0′	11h 45.1m	2°56.0′
Jupiter	♃	15	−2.5	41.9″	99%	4.70	5.06	318°17.2′	307°48.3′	20h 40.7m	−19°13.4′
Saturn	♄	15	0.6	15.4″	100%	10.76	9.96	239°31.4′	236°59.6′	15h 38.4m	−17°33.1′
Uranus	⛢	15	5.7	3.6″	100%	19.70	19.10	257°32.3′	255°24.8′	16h 56.3m	−22°40.9′
Neptune	♆	15	8.0	2.2″	100%	30.58	30.25	272°54.9′	271°24.2′	18h 05.8m	−22°20.4′
Pluto	♇	15	13.8	0.1″	100%	30.67	29.75	214°35.9′	214°23.0′	14h 29.9m	2°13.5′

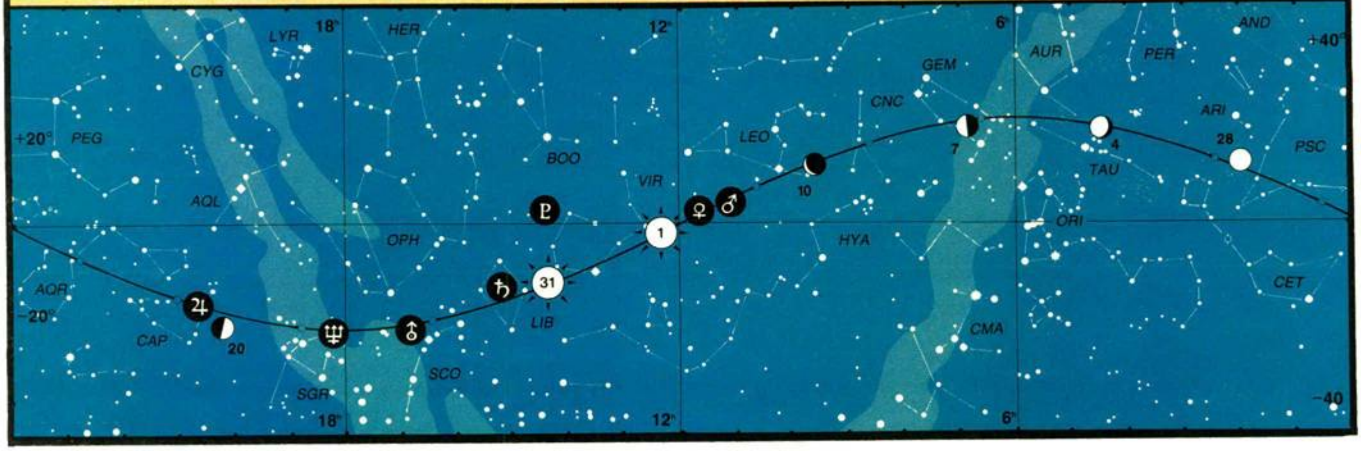

Inner Solar System
Mars
Venus
Earth
Mercury


Comet Halley
Mars
Earth
Jupiter
Pluto
Saturn
Uranus
Neptune
Outer Solar System

Moon Data

Last Quarter	October 7 at 5h04m
New Moon	October 14 at 4h33m
First Quarter	October 20 at 20h13m
Full Moon	October 28 at 17h38m
Last Quarter	November 5 at 20h07m

Apogee: Oct. 2 at 13h20m	405,764 km.
Perigee: Oct. 15 at 0h51m	358,282 km.
Apogee: Oct. 29 at 21h51m	406,313 km.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CNC
+20°
PEG
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CMA
SCO
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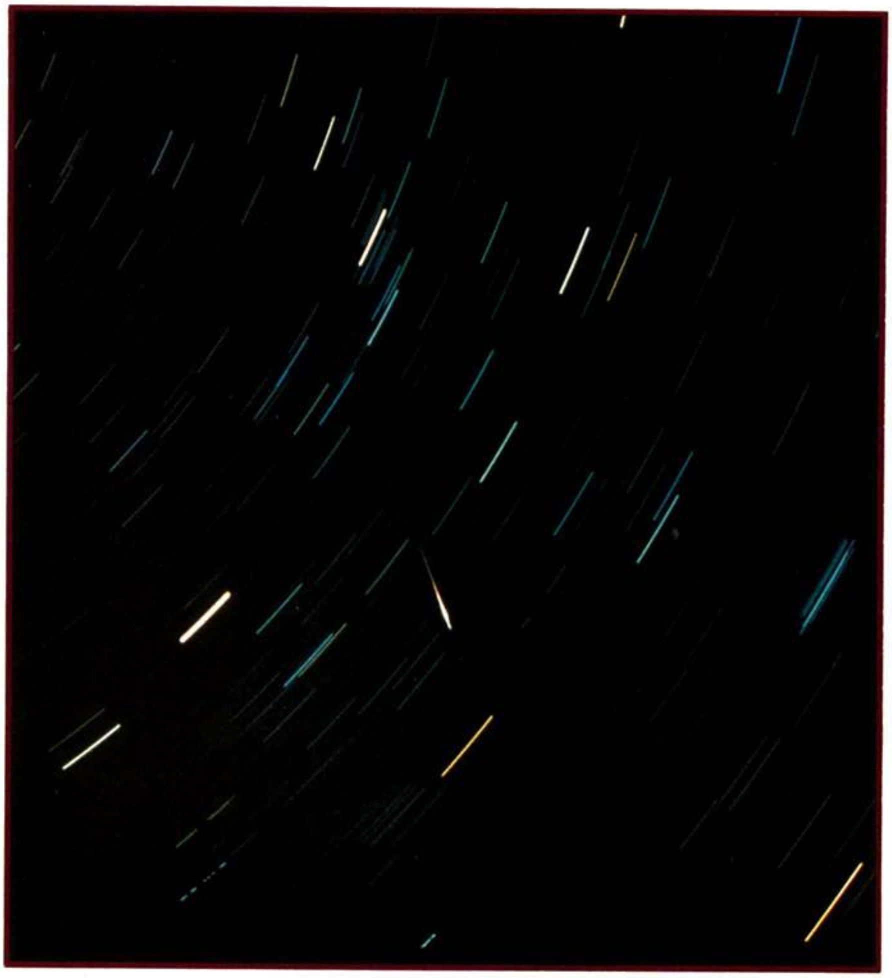


A Perseid meteor streaks down across star trails over Pine Mountain, Oregon. David Stott took the photo in August 1983 with a 20-minute exposure, Ektachrome 400 film, and a 35mm lens.

Mercury

Although it passed superior conjunction with the Sun on September 22nd and moved into the evening sky, Mercury will be hard to see. Even by the end of October, it won't be more than 3° high in the southwest as twilight ends — technically visible, but so low as to offer only very poor telescopic viewing. Save your efforts for the upcoming morning apparition in December and January.

Venus

Venus is still a brilliant object above the eastern horizon as morning twilight begins, but is sinking lower each morning. In your telescope, you'll see a roundish white dot whose dazzling brilliance slowly fades as dawn brightens the sky around it.

On the 4th, Venus will lie very close to Mars. Low to medium-power eyepieces — up to about 50x, say — will place them in the same field of view.

Moon

On October 28th, the Full Moon will pass through the southern half of Earth's shadow. Unfortunately, the event is invisible for observers in the western hemisphere. The umbral (total) phase begins at 15h 55m UT and ends at 19h 30m, with mid-totality occurring at 17h 42m. Two weeks after (November 12th), there'll be a total solar eclipse, but this is visible (either the total or partial phases) from only the southern Pacific and Atlantic Oceans, the southern tip of South America, and Antarctica.

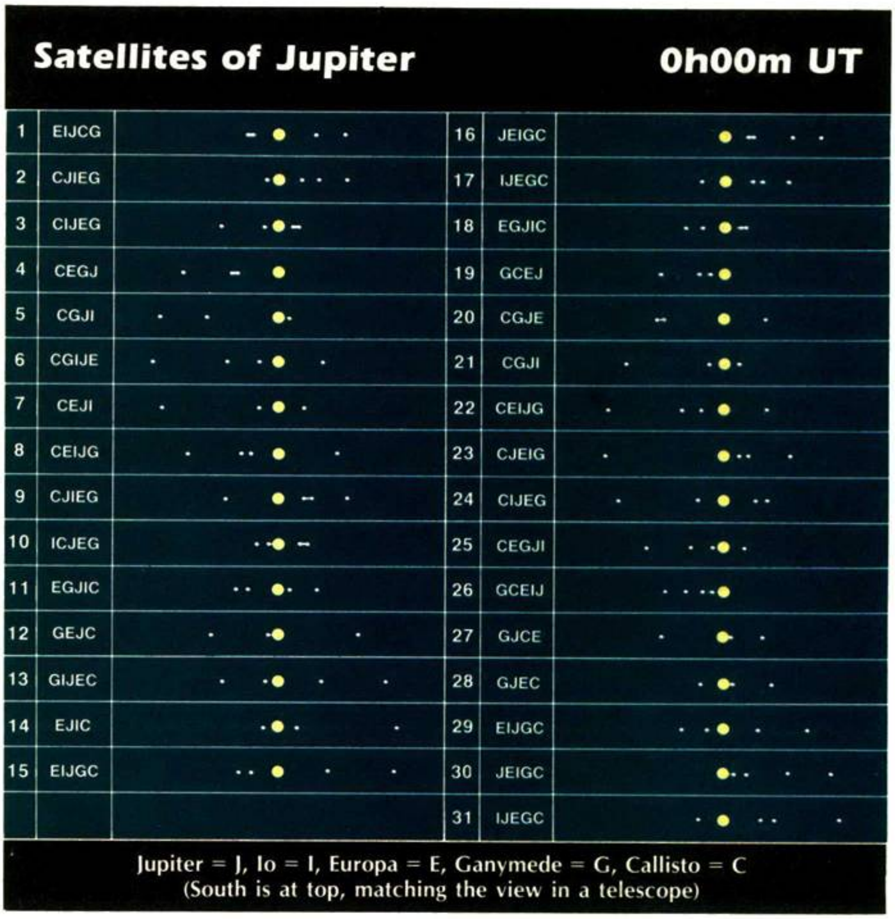
Mars

Rising a little earlier each morning, Mars is gaining in visibility. At a distance of some 2.5 astronomical units — 375 million kilometers — Mars is but a small orange dot of light, even at medium to high powers in a telescope. As the Red Planet rises higher and morning twilight grows stronger, see if your views of it improve. Dawn reduces the contrast between planet and sky, making it easier to see the dark markings on the disk, and the increased elevation helps by providing thinner and steadier layers of atmosphere to look through.

Minor Planets

In a telescope, the minor planets (once termed "the vermin of the skies" for their abundance, and known by name and discovery number) always look like tiny star-like points of light — hence their alternate name, asteroids. Since they lack the tell-tale disks of larger planets, you can detect minor planets only by their slow motions against the background (real) stars. They don't look like much, but finding and following an asteroid is an interesting observing challenge.

1 Ceres (magnitude 8.3) is moving eastward into the Sickle of Leo. A crescent



Jupiter = J, Io = I, Europa = E, Ganymede = G, Callisto = C
(South is at top, matching the view in a telescope)

Right: Darkroom manipulation turned a b&w photo of Comet Bennett into this multi-colored extravaganza and won Fred Espenak October's $100 "Best Astro-Photo" award. Left: The globular cluster M-2 in Aquarius is a seasonal beauty, visible in small instruments at medium magnifications. Photo by Scott Rosen (8-inch Schmidt-Cassegrain with focal-reducer, 20 minutes at f/5.5 on hypersensitized VR-1000 film).

Moon three days past Last Quarter will lie near it in the morning sky on October 10th. Ceres' positions:

1st: 9h 31m 45s, 20° 42.8'
10th: 9h 46m 36s, 19° 58.2'
20th: 10h 02m 27s, 19° 10.2'
30th: 10h 17m 31s, 18° 25.5'

Ceres rises about 2:30 a.m. local daylight time on the 15th.

2 Pallas (8.3) is moving southeastward in Lepus and Canis Major, about 45 minutes of right ascension west of Sirius. Its positions:

1st: 6h 00m 21s, −15° 17.1'
10th: 6h 09m 09s, −17° 48.8'
20th: 6h 16m 52s, −20° 43.7'
30th: 6h 22m 04s, −23° 39.2'

Pallas rises around 1 a.m. local daylight time on the 15th.

4 Vesta (7.8) slides eastward from Libra through Scorpius into Ophiuchus during October. About mid-month, it lies 5° north of Antares. Vesta's positions:

1st: 15h 54m 54s, −18° 03.9'
10th: 16h 12m 52s, −19° 14.9'
20th: 16h 33m 36s, −20° 24.7'
30th: 16h 55m 00s, −21° 24.0'

Vesta sets around 8 p.m. local daylight on the 15th.

15 Eunomia (8.7) is moving retrograde (westward) in northern Pisces; it lies between the galaxy M-33 in Triangulum and the star Alpheratz (Alpha [α] Andromedae), which marks the upper left corner of the Great Square of Pegasus. Eunomia's positions:

1st: 1h 26m 36s, 31° 29.0'
10th: 1h 18m 48s, 31° 20.3'
20th: 1h 10m 10s, 30° 39.4'
30th: 1h 01m 35s, 29° 30.6'

Eunomia is visible nearly all night.

To locate a minor planet, plot its dated positions lightly in pencil on a good star atlas (the *Sky Atlas 2000.0*, for example), and sketch a smooth curve linking them. Then observe the appropriate starfield at low power and photograph or plot by hand what you see. Check the field again the next night — the faint "star" that's moved is it!

Jupiter

The bright, untwinkling object in the southeastern sky after sunset is Jupiter. Using low power with your telescope, you'll see a creamy-white oval with up to four little points of light alongside it — the Galilean moons. It's fun to watch these four worldlets shuttle back and forth from night to night. (If you observe with binoculars, you'll recreate the view Galileo saw back in 1609 when he discovered them with the world's first astronomical telescope.)

Jupiter itself has dusky banded markings across its face. These dark belts and light zones of cloud sweep endlessly around the planet, pacing out the 9h 56m jovian day. The famed Red Spot — which will look more like the "Pale Reddish-Grey Spot" in your scope — is a gigantic southern hemisphere storm whose intensity waxes and wanes from year to year. Use medium to high power to look for it.

Saturn

Compared to Jupiter's varied cloud belts, Saturn offers distinctly less to see. But with its rings to look at, who cares? However — the Sun is moving steadily closer toward Saturn's celestial position and the planet is sinking swiftly into the evening twilight. Go out early in the month and set up the scope where you have a low southwestern horizon. Find Saturn swimming in the murk, marvel at its beautiful rings — and say good-bye. You won't get a good view of it again until it emerges out of the morning twilight in December or January.

Uranus

For anyone observing with the naked eye, the solar system ends at Saturn. Although Uranus lies just within the range of unaided eyesight (magnitude 5.7), it's really a binocular and telescopic object — especially considering the light-polluted skies most people must observe under. Yet how easy it is to pick up, once you've found the right field of view!

Uranus is in the southwestern sky with Saturn, but has about twice the elevation and lies some 20° to the east. Locate it by centering Antares (Alpha [α] Scorpii) in your finderscope, and then scan 3° to the left and 6.5° straight up. Uranus ought to be in the main scope's low-power field of view. When you've found it, you'll know — Uranus appears bright greenish-blue and has a 3.6" disk that's visible at low to medium magnifications.

Neptune

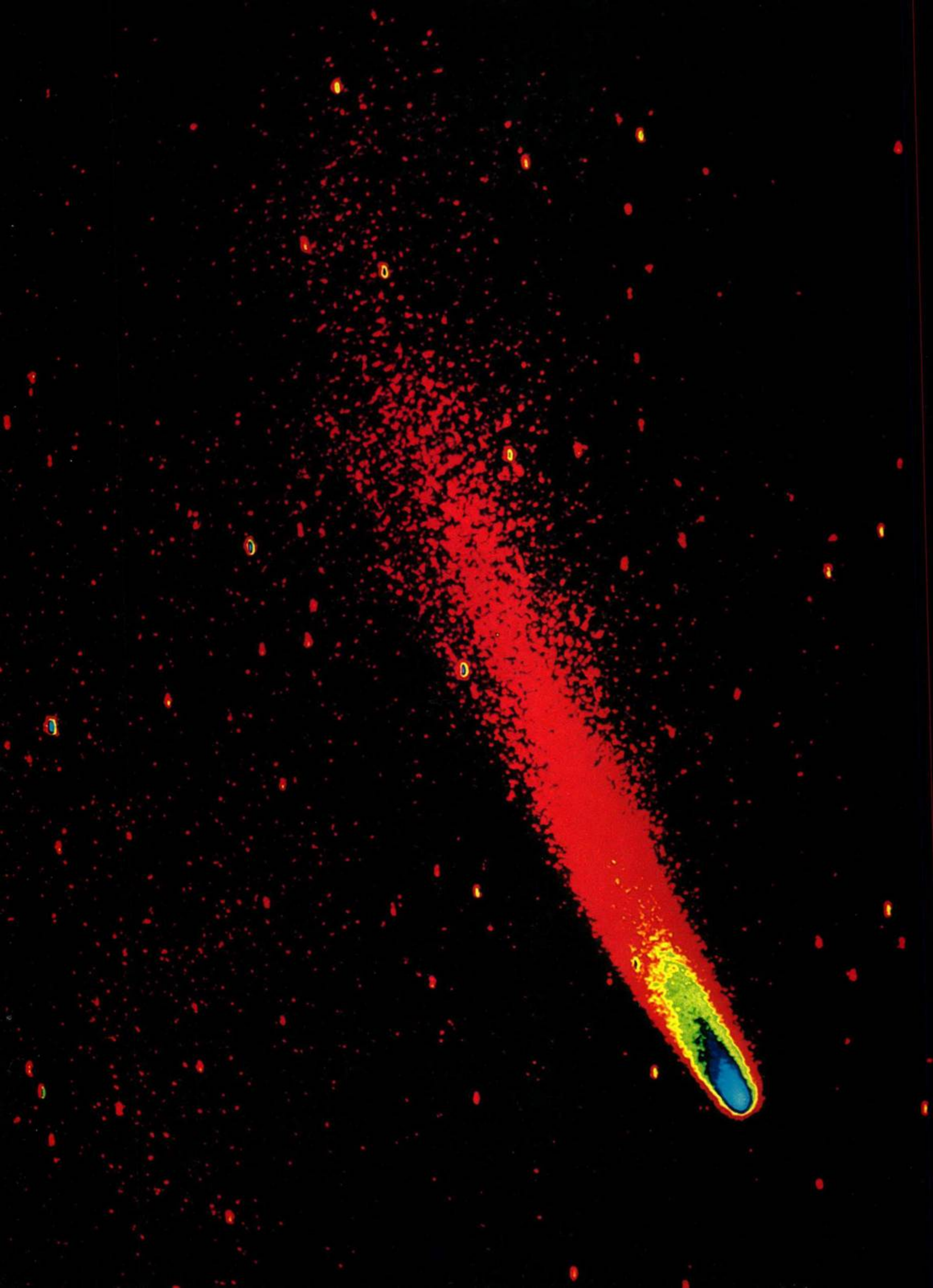
Smaller and over two magnitudes fainter than Uranus, Neptune is more difficult to locate and observe. It lies hidden in the rich starfields of the Milky Way in Sagittarius, but has several bright and pretty guideposts pointing the way to it. Start by locating the Lagoon Nebula (M-8) in your finderscope. Then scan north to find M-20, the Trifid Nebula. From M-20, sweep northeast about 1° through a rich little grouping of stars until you spot the small open cluster M-21. Neptune lies about 10' beyond M-21 in the same direction you have been scanning; look for a magnitude 8.0 object with a 2.2" disk colored greenish grey.

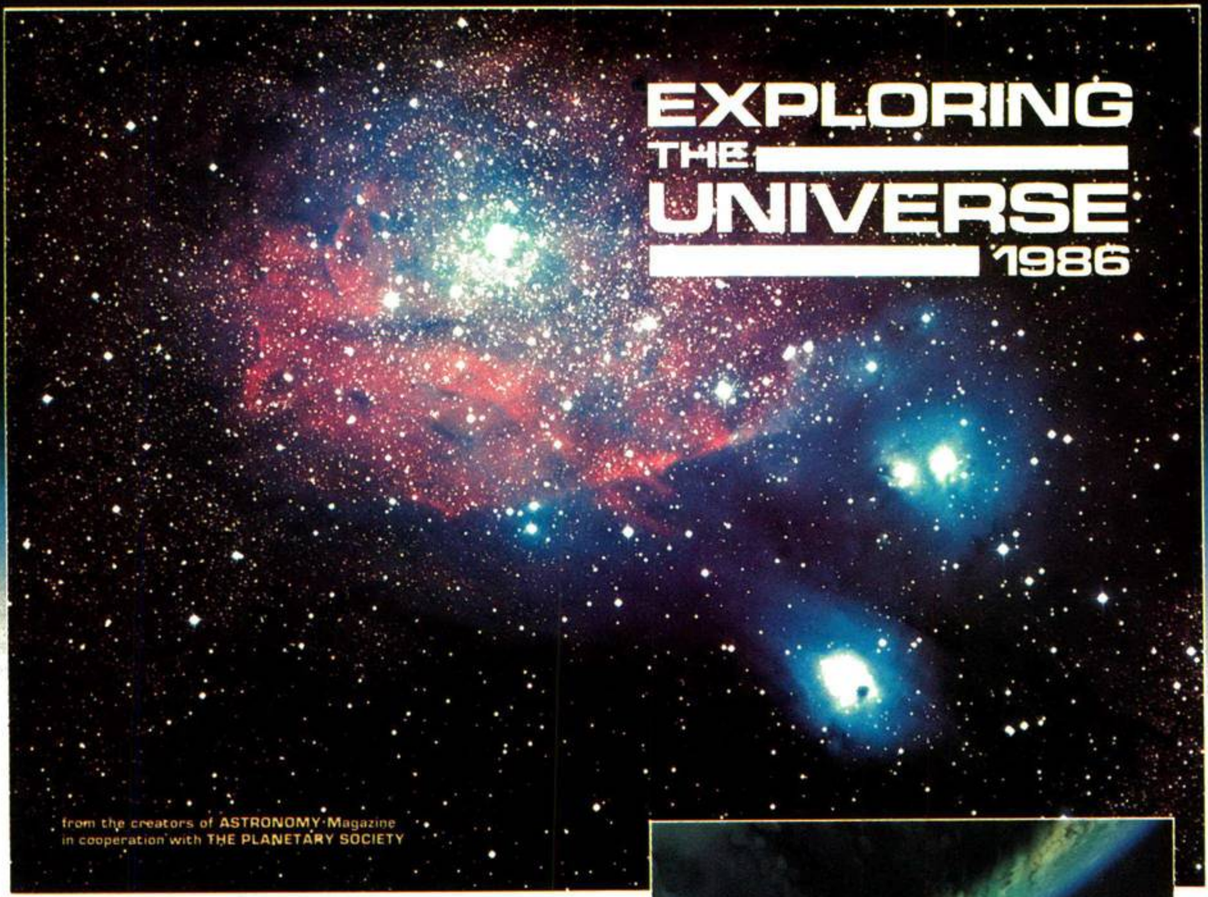
Comet Halley

October's the month when the comet "takes off the brakes" and really begins to move across the sky. For a finder map, see pages 36 and 37 of the August issue, or the one on page 9 of this issue. During October, Halley is predicted to brighten from magnitude 11.2 to 8.8 — a substantial increase which should move it from the "6-incher" category to being visible in ordinary binoculars. But brightness predictions are only educated guesses, so we'll have to see just how bright the comet turns out to be.

Universal Time

Astronomers the world over use an unambiguous system of time reckoning — Universal Time (UT) — based on a 24 hour clock. Times given in The Backyard Astronomer are UT unless noted otherwise. To convert UT into your local daylight time, subtract the following number of hours for each time zone: EDT, 4; CDT, 5: MDT, 6; PDT, 7; Alaska, 9. For example, if an event is to happen at 3h00m UT on June 7th, then EDT for the event is 11 p.m., June 6th. Likewise, 13h00m UT on September 2nd becomes, in PDT, 6 a.m., September 2nd.

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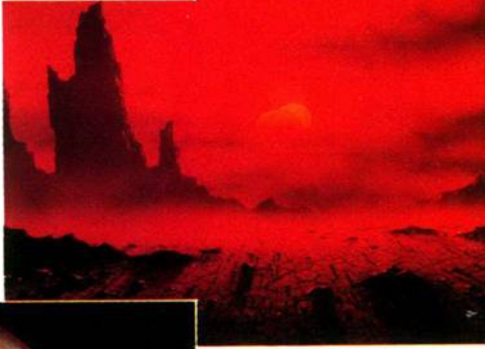

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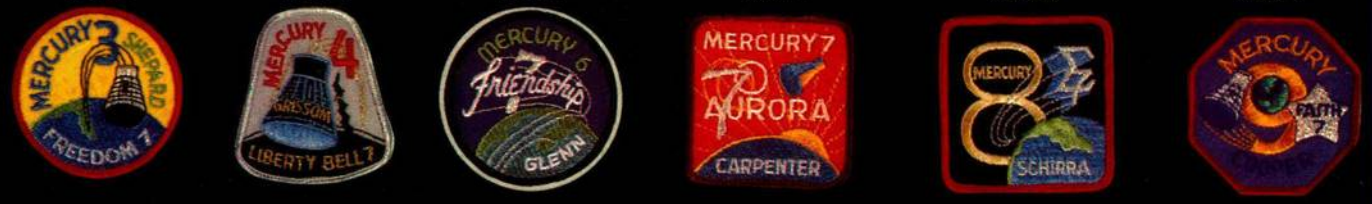

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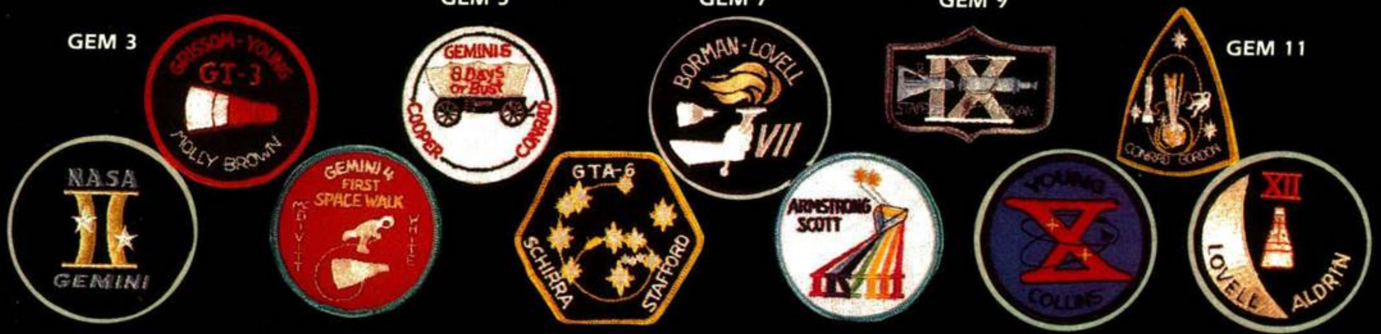

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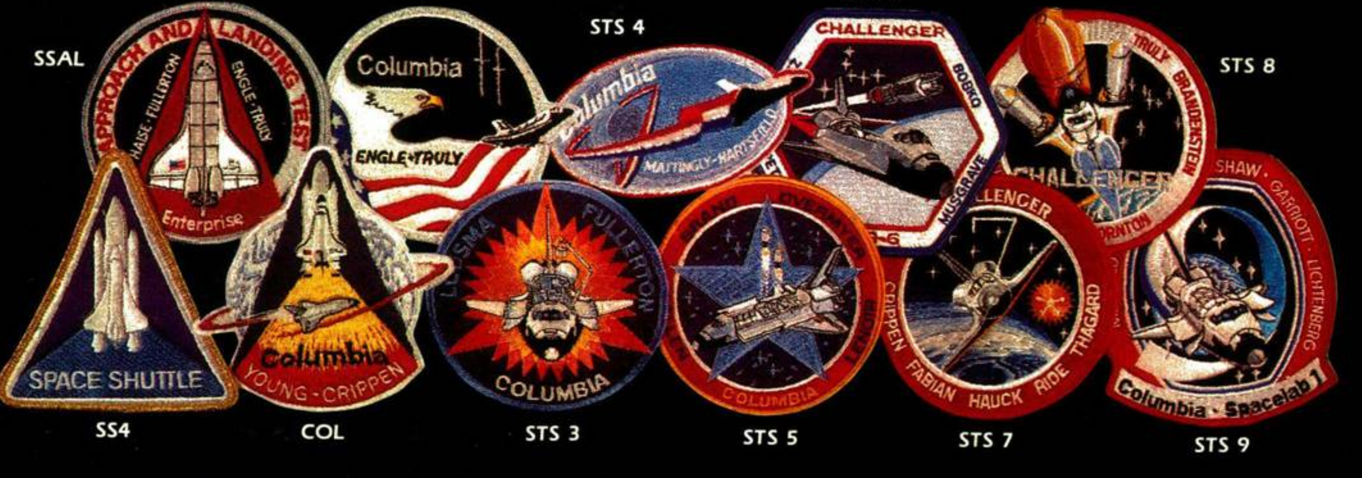

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